THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IX.

No. IV.—APRIL, 1902.

ORIGINAL ARTICLES.

I.—Woodwardian Museum Notes: Salter's Undescribed Species. VII.[1]

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE VII.)

CEPHALOPODA.

Trochoceras spurium, Salter, 1873. (Pl. VII, Fig. 1.)

1873. *Trochoceras spurium*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 160 (*a* 466).
1882. *Trochoceras striatum*, Blake: Brit. Foss. Ceph., p. 222, pl. xxix, fig. 5; pl. xxx, figs. 3, 4, 4*a*, 4*b*.
1891. *Trochoceras striatum*, Foord: Cat. Foss. Ceph. Brit. Mus., p. 32.
1891. *Trochoceras spurium*, Woods: Cat. Type Foss. Woodw. Mus., p. 131.

Salter's original specimen comes from the Wenlock Shale, Builth Bridge, and was described (Salter, loc. cit.) as having "much narrower whorls than *Phr. nautileum*." The specimen consists only of the greater portion of the outer whorl, including the body-chamber, and it shows the aperture and ornamentation very well preserved. It agrees with Blake's species *Tr. striatum* in shape, rate of increase, characters of body-chamber and aperture, degree of obliquity of the transverse ribs, their absence on the body-chamber, the fine lines parallel to them on the rest of the whorl, the epidermids, and the shape, position, and distance apart of the septa. The stratigraphical horizon on which it is found is also the same, and there can be no doubt that the species are identical, as they agree in all the essential characters and even in every minute detail.

Orthoceras fluctuatum, Salter. (Pl. VII, Fig. 2.)

1873. *Orthoceras fluctuatum*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 37 (*a* 611).
1882. *Orthoceras fluctuatum*, Blake: Brit. Foss. Ceph., p. 122 (cf. *O. recticinctum*, Blake).
1891. *Orthoceras fluctuatum*, Woods: Cat. Type Foss. Woodw. Mus., p. 129.

Salter describes this species as possessing "coarser striæ than *O. subundulatum*, Portl., and apparently more bent still than in that species." The single specimen (*a* 611) named by Salter comes from the Lower Bala (Llandeilo) of Wellfield, Builth, and consists of an imperfect external hollow cast of a portion of the shell, showing

[1] For previous articles see Geol. Mag., 1901, pp. 5, 106, 246, 355, and 576; 1902, p. 122.

a series of undulating, equidistant, regular, transverse, coarse striæ, six in a space of 4 mm. These striæ on the cast would be represented on the surface of the shell by raised thread-like lines. But this material is absolutely insufficient for the creation of a new species, and Blake (loc. cit.) hesitates in identifying it with *O. recticinctum*, partly on the ground of its imperfect preservation and partly because it comes from a different geological horizon. It seems advisable, therefore, to let the name drop, as the original specimen does not admit of a sound species being established.

LAMELLIBRANCHIATA.

Pterinea exasperata, Salter. (Pl. VII, Figs. 3–5.)

1873. *Pterinea exasperata*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 150 (*a* 813, *a* 814, *a* 815, *a* 816).
1891. *Pterinæa exasperata*, Woods: Cat. Type Foss. Woodw. Mus., p. 89.

The specimens labelled *Pterinea exasperata* by Salter are eleven in number. All are from the Wenlock Limestone of Dudley and belong to the Fletcher Collection. One has both valves preserved, though the right one is somewhat imperfect. The others are all left valves, and one (*a* 815) shows the inner side of this valve. Five more specimens of this species have been acquired since 1873. Salter (loc. cit.) described it as "a reticulate species, long known but not yet described."

Diagnosis.—Body of shell obliquely ovate, elongate, unequally biconvex; long straight hinge-line; left valve slightly more convex than the right; furnished with small rounded, triangular anterior ear and large flattened posterior wing.

Left valve with obliquely elongate convex body; beak gibbous, prominent; anterior ear not sharply marked off from body; posterior wing large, pointed, more than two-thirds the length of posterior slope, depressed, flattened, more or less distinctly marked off from body, posterior margin concave. Hinge-line long, straight, making angle of about 30°–40° with body behind umbo.

Surface of body marked by strong, straight, radiating, narrow, equidistant ribs, 25 to 35 in number, very feebly developed or absent on anterior and posterior ears. Half-way between each pair of these main ribs is a finer, thread-like rib which begins at some distance from the beak, and increases in strength towards the margin so as ultimately to be equal in size to the main ribs. Ribs crossed by regular, equidistant, concentric, scale-like lamellæ, arched backwards towards the umbo between each pair of main ribs, and between every pair of ribs near the ventral margin. The lamellæ are continued on to the ears, where they are more closely packed together and crenulated, and on the posterior ear are parallel to the concave posterior margin. Right valve rather less convex than left valve, but in other respects apparently similar.

Measurements.	I.	II.	III.
	mm.	mm.	mm.
Length along oblique axis of body ...	30	30	43
Length at posterior end	21	23	31
Width along hinge-line	24	22	28

Remarks.—A species which appears to be closely allied to this form is *Pt. fimbriata*[1] (McCoy), from the Silurian (Wenlock?) of Dingle, co. Kerry. This Irish species differs, however, in being less elongated, in possessing a shorter posterior wing and a more acute umbo, but the ornamentation of the surface closely agrees. McCoy figures only a right valve. From *Pt. subfalcata* (Conr.) our species differs in the regularity and strength of its concentric lamellation, in its larger posterior ear, and the different shape of its anterior ear.

Pterinea condor, Salter. (Pl. VII, Figs. 6 and 7.)

1873. *Pterinea condor*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 169 (*a* 809, *a* 810).
1891. *Pterinæa condor*, Woods: Cat. Type Foss. Woodw. Mus., p. 89.

There are three specimens labelled *Pterinea condor* by Salter, but one of these (*a* 810) is probably due to a mistake, as it obviously belongs to an entirely different species. The specimens all come from the Lower Ludlow beds of Dudley and belong to the Fletcher Collection. Salter describes it as having "very wide hinge line, three inches broad."

Diagnosis.—Shell transversely oblong, very inequivalve, flattened. Hinge-line long, straight. Left valve weakly convex, flattened posteriorly into large posterior wing, which is bluntly pointed behind, slightly excavated along posterior margin, and extended along upper margin beyond body of shell. Hinge-line longer than shell. Anterior ear very small, depressed below body of valve. Umbo small, prominent, rising above hinge-line. Distinct band along hinge-line marked off from posterior wing, representing ligamental facet. Surface of valve marked by faint concentric striæ parallel to margins.

Right valve (? of same species), Fig. 7, subquadrate, flattened. Upper and anterior margins straight, meeting at angle of 120°, each furnished with longitudinally striated, band-like area, of which the upper is marked with five longitudinal shallow grooves, interrupted along part of their length near anterior end. Posterior margin broadly rounded, weakly emarginate at inferior angle. Inferior margin rounded, meeting anterior margin at nearly a right angle. General surface of valve feebly convex, especially in central part of hinge-line. Oval muscular impression in anterior angle between upper and anterior margins.

Measurements.

	mm.
Left valve.	
Width (along hinge-line)	74
Length	40
Right valve.	
Width (along hinge-line)	31
Length	32

Remarks.—This form most resembles *Pterinea retroflexa*, var. *naviformis* (Conr.), but differs in its more extended hinge-line and more pointed posterior wing, as far as the left valve is concerned.

[1] McCoy: Silur. Foss. Irel., 1846, p. 21, pl. ii, fig. 7; Brit. Pal. Foss., 1851, p. 263, pl. ii, figs. 3, 3*a*.

The great inequality and difference of shape of the opposite valves ascribed to the same species are also characteristic and peculiar features.

EXPLANATION OF PLATE VII.

FIG. 1.—*Trochoceras spurium*, Salter (*a* 466). Wenlock Shale: Builth Bridge. Drawn nat. size.
FIG. 2.—*Orthoceras fluctuatum*, Salter (*a* 611). Lower Bala (Llandeilo): Wellfield, Builth. × twice nat. size.
FIG. 3.—*Pterinea exasperata*, Salter (*a* 816). Wenlock Limestone: Dudley. × $1\frac{1}{2}$ nat. size.
FIG. 4.—Ditto (*a* 813).
FIG. 5.—Ditto (*a* 816), 4 ribs enlarged 4 times nat. size, to show ornamentation.
FIG. 6.—*Pterinea condor*, Salter (*a* 809). Lower Ludlow Beds: Dudley. Left valve. Nat. size.
FIG. 7.—Ditto, right valve (*a* 810), nat. size.

II.—ON *CAMPYLOPRION*, A NEW FORM OF *EDESTUS*-LIKE DENTITION.

By Dr. C. R. EASTMAN, of Cambridge, Mass., U.S.A.

(PLATE VIII.)

IN the January number of the GEOLOGICAL MAGAZINE for 1886, an elaborate description is given by Dr. Henry Woodward of a peculiar ichthyic structure from the Carboniferous of Western Australia, which is referred by him provisionally to *Edestus*, under the specific title of *E. davisii*. Interesting comparisons are drawn between this and other known species of *Edestus*, and the hypothesis advanced that it is a pectoral fin-spine, resembling in its segmented character the Cretaceous *Pelecopterus*. This segmentation, which is so conspicuous a feature of *Edestus*, is attributed by Dr. Bashford Dean in his book on "Fishes, Living and Fossil," to a metameral origin, and he follows Leidy, Owen, Cope, Newberry, and others in interpreting all this class of remains as dorsal fin-spines.

As early as 1855 Louis Agassiz[1] compared the type-specimen of *Edestus minor*, Newberry, with the rostral prolongation of *Pristis*, and pronounced it a dermal defence, pertaining probably to the snout region of a shark or skate. Quite recently this hypothesis has been revived by Dr. A. Karpinsky, Director of the Russian Geological Survey, in his superb memoir on *Helicoprion*,[2] a spirally coiled form whose segments resemble those of *Edestus*, and is regarded by the author as a powerful weapon placed above the snout in the median line. To this Permo-Carboniferous genus, *Helicoprion*, the Russian Director also refers the Australian form described by Dr. Henry Woodward as *Edestus davisii*, which differs principally in the lesser extent of its spiral. In an appreciative review of his monograph, Dr. Arthur Smith Woodward[3] questions the probability of Karpinsky's conjecture, and cites a recent discovery made by Dr. Traquair in the Lower Devonian of Forfarshire, which "proves

[1] Proc. Amer. Assoc. Adv. Sci., 1855 (1856), p. 229.
[2] Verh. k. russ. min. Ges. St. Petersburg, 1899, ser. II, vol. XXXVI, No. 2.
[3] GEOL. MAG., 1900, Dec. IV, Vol. VII, p. 33.

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× 1½

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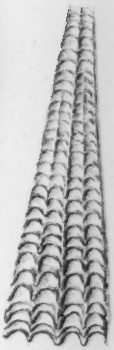
× 2



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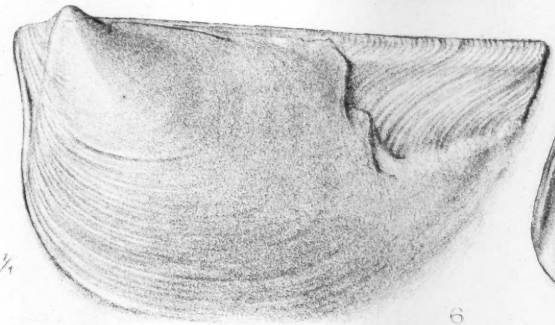

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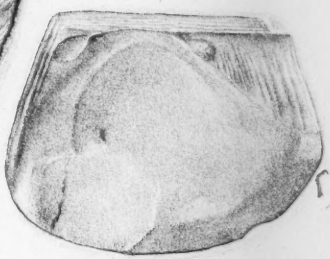

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G. M. Woodward del. et lith.

West, Newman imp.

Ordovician and Silurian Mollusca.

FIG. 1.

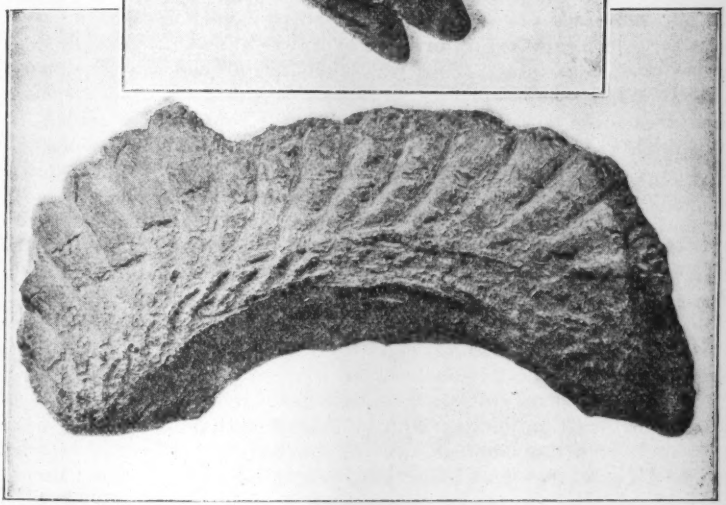

FIG. 2.

Symphysial Teeth of Palæozoic Sharks.

FIG. 1.—*Campodus variabilis* (Newb. & W.): Coal-measures, Cedar Creek, Nebraska.
FIG. 2.—*Campyloprion annectans*, C. R. Eastman, gen. et sp. nov. (loc. unknown).
(About one-third natural size.)

undoubtedly that there were Palæozoic sharks with sharp, piercing teeth, which were never shed, but became fused into whorls as the animal grew."

The same memoir was also reviewed by the present writer,[1] who brought forward additional instances of coiling amongst Palæozoic sharks, and was inclined to look upon the segments of *Helicoprion* as veritable teeth. Finally, a fortunate discovery of the symphysial dentition of the Carboniferous genus *Campodus*, made by Professor E. H. Barbour, Director of the Nebraska University Geological Survey, threw new light on the matter, and furnished ground for a positive statement that the fused segments of *Edestus* and *Helicoprion* are actually teeth belonging to the anterior series of Cestraciont sharks. The evidence for this was presented by the writer before the Denver meeting of the American Association for the Advancement of Science, and in the published abstract of that paper[2] the arrangement of the anterior series in *Campodus variabilis* (Newb. & W.) was briefly described. A second specimen in the Museum of Comparative Zoology at Cambridge, Mass., from the Coal-measures of Osage County, Kansas, exhibits the symphysial series in natural association with the lateral. Professor Barbour's specimen, shown in the accompanying Plate VIII, Fig. 1, is more perfect in some respects, but has none of the lateral series associated with it.

Each individual of *Campodus* is known to have possessed at least three series of coalesced anterior or symphysial teeth. As indicated by the marks of contact, there was a median arched azygous series in one jaw (presumably the lower, as is the case in *Cestracion*, *Chlamydoselache*, and other existing sharks), opposed to which in (presumably) the upper jaw were two corresponding series separated from each other by a slight interval. The orientation of both the symphysial and lateral teeth of *Campodus* may be determined from the fact that their coronal buttresses are directed outward, instead of inward, as was erroneously supposed by Messrs. St. John and Worthen. Several series of anterior teeth, all coiled in a single plane, are known to have been present in the same mouth of *Campodus*, *Protodus*, *Periplectrodus*, and certain Cochliodonts, hence it is probable that a like condition was true of *Edestus* and *Helicoprion*. In the two last-named genera it was rightly pointed out by Smith Woodward that the absence of lateral facettes or marks of contact with adjoining whorls indicates that the series were separated from one another, as in the existing *Chlamydoselache*. In the light of the now clearly apparent odontological nature of *Edestus* and *Helicoprion*, together with their Cestraciont affinities, it may be pertinent to inquire whether the huge fin-spines from the Carboniferous, such as *Oracanthus*, *Phoderacanthus*, *Stichacanthus*, and the like, were not borne by creatures having an *Edestus*- or *Campodus*-like dentition.

[1] Amer. Nat., 1900, vol. xxxiv, p. 579.
[2] Science, N.S., 1901, vol. xiv, p. 795.

DESCRIPTION OF *CAMPYLOPRION ANNECTANS*, gen. et sp. nov.
(Pl. VIII, Fig. 2; and Woodcut, Fig. 3, in text.)

In the same category with *Edestus* and *Helicoprion* must be placed a new genus of Palæozoic Cestracionts, known as yet only by its symphysial dentition, for which the name *Campyloprion* is proposed, with the type species of *C. annectans*. This is founded on a unique specimen belonging to Tufts College Museum, Boston, the description of which follows. The new genus is also held to include two species originally assigned to *Edestus*, namely, *E. davisii*, Woodward, and *E. lecontei*, Dean. The former of these has been discussed in its relations to other *Edestus*-like structures by Woodward, Dean, and Karpinsky, and was transferred by the last-named author to *Helicoprion*. For the sake of comparison we may briefly summarize the distinguishing characters of these four closely related genera, as follows:—

1. *Campodus*.—Anterior series of thirteen or more teeth fused into a semicircular arch, their outer (anterior) coronal margins prominently buttressed, and their coronal apices rather obtuse and not serrated; the teeth only slightly overriding one another at their extremities, not much laterally compressed, and very much larger than the immediately adjoining lateral series, which also have their buttresses directed outward. Type, *C. agassizianus*, Koninck.

2. *Edestus*.—Anterior series of seven or more fused teeth only moderately arched and laterally compressed; coronal apices acuminate and serrated along the sharpened anterior and posterior margins; bases strongly reflected forward, invaginated, and fused throughout. Lateral series unknown. Type, *E. vorax*, Leidy.

3. *Campyloprion*.—Anterior series of twenty or more fused teeth considerably arched and much laterally compressed; coronal apices rather obtuse, and coarsely serrated along the sharpened anterior and posterior margins; teeth curved or bent forward, overriding one another toward their extremities and fused for the greater portion of their length. Type, *C. annectans*, sp. nov.

4. *Helicoprion*.—Anterior series consisting of upwards of 150 fused teeth, very similar to the last in form, but coiled into approximately 3½ whorls; coronal apices acute and finely serrated along the sharpened anterior and posterior margins; enamel extending far down the lateral faces; teeth more or less strongly curved forward, overlapping and fused for a portion of their length; two lateral grooves extending along the spiral near the bottom. Lateral series unknown. Type, *H. bessonowi*, Karpinsky.

Arranged in the above order we are enabled to note the progressive stages by which the typical Cestraciont dentition of *Orodus* and *Campodus*, occurring in the Carboniferous, passed into the excessively modified spirals of *Helicoprion* in the Permian. Moreover, the chief interest attaching to *Campyloprion* is on account of its intermediate position, two of its species linking it with *Edestus*, as already observed, and a third, as denoted by its trivial title, marking the transition to *Helicoprion*.

For the opportunity to describe the interesting series of teeth shown in Plate VIII, Fig. 2, and section in text, Fig. 3, the writer is indebted to his friend Dr. J. S. Kingsley, of Tufts College, in whose custody it has been for many years. Unfortunately nothing is known of the history of the specimen prior to its coming to Tufts, except that it was procured for the Museum by the late Professor Marshall. While its age may be confidently attributed to the Upper Carboniferous or Permian, there is no clue as to its locality. The specimen

is arcuate in form, with an extreme length of about 24 cm., and comprising twenty fused teeth, only four of which, however, are perfectly preserved. A transverse section of the specimen taken vertically from the apex of the largest tooth, where the height is about 8 cm., is shown in Fig. 3. All the teeth have suffered greatly from the effects of weathering, which has removed most of the enamel, and from post-mortem abrasion. In general form they resemble those of *Helicoprion bessonowi*, but are less angularly bent, in which respect they differ also from *C. davisii*; in addition, their apices are more obtuse and more coarsely serrated. Both of these species of *Campyloprion* differ from the Russian form in their lesser degree of curvature, and it is extremely improbable that either of them was coiled into a complete spiral. Neither do they exhibit the double lateral grooves which traverse the spirals of *Helicoprion*. It is possible that the indistinct patches of enamel observed along the base of the present specimen may represent an adjacent series of small teeth, such as occur in juxtaposition to the symphysial series of *Campodus variabilis*. A more detailed account of the dentition of the latter form will be given in a forthcoming number of the Bulletin of the Museum of Comparative Zoology.

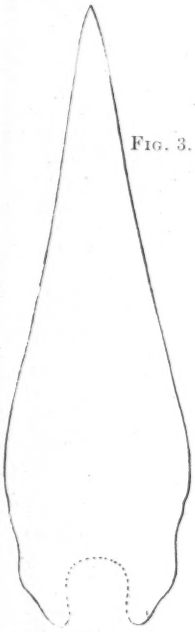

Fig. 3.

Vertical section of Fig. 2. *Campyloprion annectans.*

EXPLANATION OF FIGURES.

Pl. VIII, Fig. 1.—*Campodus variabilis* (Newb. & W.). Coal-measures: Cedar Creek, Nebraska. Symphysial series of teeth belonging (presumably) to the lower jaw, viewed from the right-hand side. Original preserved in the Museum of Nebraska State University at Lincoln. Reduced to about one-half nat. size.

Pl. VIII, Fig. 2.—*Campyloprion annectans*, gen. et sp. nov. Carboniferous or Permian: locality unknown. Left lateral aspect of a portion of the anterior dentition, showing portions of 20 coalesced teeth, supported at their bases by a band of calcified cartilage. Reduced.

Fig. 3 (in text).—*Campyloprion annectans*. Vertical cross-section of specimen shown in Fig. 2, passing through apex of largest tooth in the series. Reduced to about one-third nat. size.

III.—The Ventral Integument of Trilobites.[1]

By Professor Charles E. Beecher, Ph.D., For. Corr. Geol. Soc. Lond., Yale University, New Haven, Conn., U.S.A.

(PLATES IX–XI.)

In previous papers by the writer on the structure and appendages of *Triarthrus*,[2] no attempt has been made to describe or illustrate the character of the ventral integument, especially in the sternal or

[1] Reprinted by permission from the Amer. Journ. Sci. [4], vol. xiii (1902), pp. 165–174.

[2] C. E. Beecher, "On the Thoracic Legs of Trilobites": Amer. Journ. Sci. [3],

axial region. The specimens hitherto described were prepared to show details of the appendages, and though portions of the ventral membrane were exposed in many individuals, the subject was not considered of sufficient moment to warrant a distinct study, particularly as no characters were observed in the cuticle that had not been previously seen in more or less perfection by Walcott[1] in the genera *Ceraurus* and *Calymene*. A recent discovery by Jaekel,[2] however, necessitates the separate consideration of this structure. This necessity arises from the fact that a positive addition to the knowledge of the trilobite anatomy may be deduced, although, as will be shown, Jaekel was apparently entirely misled in his interpretation of the nature of his discovery.

In the paper under discussion, Jaekel[2] states that the occasion for his publication arose from the finding of a specimen of *Ptychoparia striata*, from the Cambrian of Bohemia, in which some structures were preserved in the axis of the six anterior segments of the thorax. These, he asserts, are the proximal joints of the legs.

The specimen was preserved as a cast in a rather coarse-grained sandstone, and is exposed from the dorsal side. From certain surface indications of lines in the cast, Jaekel was led to follow these into the rock filling the axis, and succeeded in finding a central groove, with two oblique grooves on each side. These he considered as representing the cavities left by the removal of the test from the basal joints of the legs, which thus must have been attached along the median line of the sternum. The supposed joints of the legs were filled with rock, and his attempts to separate them from the matrix resulted in failure.

In the oral region, there were still more indefinite and obscure evidences of cavities left by the removal of some ventral testaceous structure.

These meagre remains in the rachis of the thoracic and oral regions have furnished data for what must be considered as the most remarkable and erroneous reconstruction of the trilobite appendages and anatomy that has appeared since the time of Burmeister,[3] in 1843. The latter, in the absence of any material, confessedly based his opinions of the ventral anatomy wholly upon theoretical considerations. Not only has Jaekel to a large degree set aside the evidence presented by many scores of specimens of *Triarthrus*, as described by the writer, in which each detail of

vol. xlvi (1893). "On the Mode of Occurrence, and the Structure and Development of *Triarthrus Becki*": Amer. Geol., vol. xiii (1894). "The Appendages of the Pygidium of *Triarthrus*": Amer. Journ. Sci. [3], vol. xlvii (1894). "Further Observations on the Ventral Structure of *Triarthrus*": Amer. Geol., vol. xv (1895). "The Morphology of *Triarthrus*": Amer. Journ. Sci. [4], vol. i (1896); GEOL. MAG., Dec. IV, Vol. III (1896).

[1] C. D. Walcott, "The Trilobite: New and Old Evidence relating to its Organization": Bull. Mus. Comp. Zool., vol. viii, No. 10 (1881). "Appendages of the Trilobite": Science, vol. iii, No. 57 (1884).

[2] Otto Jaekel, "Beiträge zur Beurtheilung der Trilobiten," Theil i: Zeitschr. Deutsch. Geol. Gesell., Bd. liii, Heft 1 (1901).

[3] Hermann Burmeister: "Die Organisation der Trilobiten," etc., 1843.

structure can be verified indefinitely, but has also overlooked that afforded by the material illustrated by Walcott,[1] Billings,[2] Mickleborough,[3] and Woodward.[4] Moreover, this single specimen of *Ptychoparia* has led its describer to reconsider on a false premise the entire question of the anatomy, ontogeny, phylogeny, and affinities of the trilobite.

It is the purpose of the present article to show that numerous individuals of *Triarthrus*, as well as some material representing other genera, preserve evidence of what seem to be the same structures as those described by Jaekel in *Ptychoparia*, and also present indisputable testimony as to their correct nature. It will be demonstrated that they do not belong in any way to the appendicular system of the trilobites, but are really the buttresses and apodemes of the ventral body integument.

The marvellous state of preservation of many of the specimens of *Triarthrus*, whose appendages have been studied by the writer, affords very satisfactory indications, not only of the presence of a ventral integument, but also of some of its detailed characters. Jaekel states that in his opinion the *unfavourable* ("*ungünstigen*") preservation of *Triarthrus* has obscured the proximal structure of the legs, so that what he calls the three basal joints are equivalent to the single unjointed gnathobase of the coxopodite, as described by the writer. Inasmuch as Jaekel has never seen the original specimens described, his statement is practically without foundation. It may also be added that the types and best-preserved individuals have been retained in the collections of the Yale University Museum. The photographic illustrations accompanying this article, it is believed, will refute his statement, and the specimens themselves would serve the same purpose more completely, since from the black nature of the rock and the nonactinic character of the fossils the photographs feebly represent the delicate structures actually preserved, which are clearly visible to the eye.

The ventral membrane of *Triarthrus*, as well as of other trilobites where it has been observed, is of extreme tenuity, and only under the most favourable conditions has it been preserved. The membrane itself was a thin, uncalcified, chitinous, flexible pellicle, and thus was in strong contrast with the much thicker and calcified dorsal test.

In the preparation of a specimen to show the appendages from the ventral side, very little of the ventral membrane is commonly exposed, owing to the crowded arrangement of the legs, but when the appendages are removed it is possible to view the entire ventral integument. This process has been carried out in a considerable

[1] Op. cit.

[2] E. Billings, "Notes on some Specimens of Lower Silurian Trilobites": Quart. Journ. Geol. Soc., vol. xxvi (1870).

[3] J. Mickleborough, "Locomotory Appendages of Trilobites": Journ. Cinti. Soc. Nat. Hist., vol. vi, No. 3 (1883).

[4] Henry Woodward, "Note on the Palpus and other Appendages of *Asaphus*, from the Trenton Limestone, in the British Museum": Quart. Journ. Geol. Soc., vol. xxvi (1870).

number of specimens, and some of the more evident characters are herewith described.

The membrane under each pleuron (pleurotergite, Jaekel), or the pleurosternite, as it may be termed,[1] was smooth and extremely thin, and in the fossils it is invariably concave. This was probably

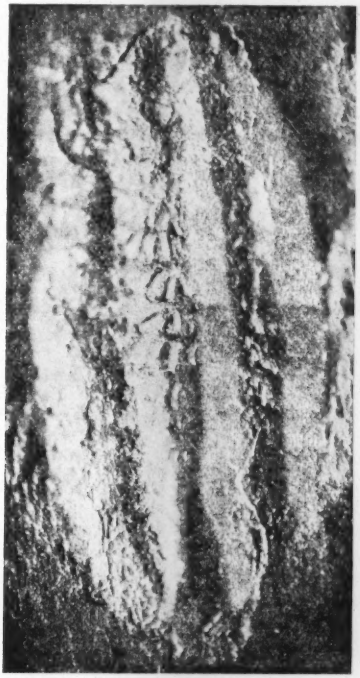

Fig. 1.—A specimen of *Triarthrus Becki*, Green; viewed from the ventral side. The appendages have been removed and the ventral membrane exposed. In the glabellar region are seen the hypostoma, and just below it the semicircular convex metastoma with side lappets. Below, in the axial region, the buttresses and thickenings of the sternal arches are clearly marked, as described in the text. Enlarged about nine diameters.

the condition during life, to allow space for the biramous legs and for their infolding during enrolment. It should be noted, however, that the dorsal and ventral integuments in the fossils are generally very close together throughout, leaving but a small cavity for the

[1] Jaekel has suggested the name mesotergite to supplant the terms axis or tergum, and pleurotergite in place of pleuron or epimerum, as applied to the trilobites. This seems a useful terminology since the older terms are often loosely used and have somewhat different meanings in other groups. Applying this system of nomenclature to the ventral integument, the writer would propose the terms *mesosternite* for the membrane beneath each mesotergite, and *pleurosternite* for the membrane beneath each pleurotergite. The interarticular membranes are not included.

soft parts of the animal. The space inside has doubtless been considerably reduced by partial collapse from the decay of the soft parts of the animal, and also by the pressure of the sediments. The size of the body-cavity is unquestionably more correctly shown in the specimens described by Walcott[1] and Mickleborough,[2] from the Trenton limestone and Cincinnati shales respectively, where they have apparently suffered less compression.

Walcott showed that the membrane in *Calymene* and *Ceraurus* was strengthened in each segment by a transverse arch, to which the appendages were attached at the sides of the axis. These arches were connected by a thinner membrane (the interarticular membrane), and were aptly compared to the arches in the ventral integument of many of the decapods. Similar features are present in *Triarthrus*, as illustrated in Pl. XI, Fig. 1, and Figs. 1–3 in text, where it is seen that the interarticular membrane (Fig. 3) in a normally

FIG. 2.—The same specimen enlarged only a little more than three diameters. The illumination is from the side opposite to that in the preceding figure.

extended individual is somewhat less than half the length of the arches. The chitinous integument of the arches, or mesosternites as they may conveniently be called, is thickened along the borders, and appears to be slightly incurved on the posterior edge. The arches are further strengthened by a series of median and oblique longitudinal ridges, or buttresses, which are generally progressively more developed in passing anteriorly from the pygidium along the thorax to the neck-segment of the cephalon.

The ventral arch of each segment has the following arrangement of these ridges:—There is first a median ridge generally extending from the posterior border entirely across the plate, but sometimes becoming obsolescent near the anterior border. Then, on each side, there is an oblique ridge making an angle of about sixty degrees with the posterior edge and extending inward, but not meeting the median ridge, thus enclosing a subtriangular space with the anterior apex truncated. Outside of these ridges, but still within the axial region, there is often a second pair of somewhat more oblique ridges, enclosing rhombic areas.

[1] Op. cit. [2] Op. cit.

The ridges are clearly produced by a thickening of the ventral integument, and can be seen when viewed from the dorsal side of a specimen in which the dorsal test and filling of the body-cavity have been removed. *They are thus partly or wholly of the nature of apodemes, or plates of chitin, which pass inward from the mesosternites and divide as well as support internal organs, and they are not, therefore, in any sense the proximal joints of legs.* Besides serving in this manner they were doubtless efficient in giving the necessary firmness to the ventral arches for the attachment of muscles.

FIG. 3.—*Triarthrus Becki*, Green. The ventral side of the middle thoracic region of the specimen illustrated on Plate XI; showing the ends of the pleurotergites on the outside, with the joints of the endopodites within the pleural regions, and the gnathobases extending obliquely inward in the axis. The sternal arches with their longitudinal ridges and the interarticular membranes are represented. Enlarged four and one-fourth diameters. The extensions of the limbs beyond the carapace are omitted.

Were these observations confined wholly to the specimens of *Triarthrus*, there might still be some chance of error, although it is believed that the evidence presented by this genus alone is quite sufficient. Additional data, however, will now be given, regarding other genera and families of trilobites, described independently by other authors, and with no intention of representing the detailed characters of the ventral arches. In the search for trilobite appendages by various investigators, the ventral membrane has naturally been of secondary consideration, and in the case of Jaekel's work was of no consideration whatever.

The earliest studies and illustrations of trilobites giving some evidence of the nature of the ventral membrane are those by Walcott on the genera *Calymene* and *Ceraurus*. The limitations of the ventral body-walls of the animal were clearly shown by a marked change in the colour of the rock between the white calcite filling the body-cavity and the dark limestone matrix. In Fig. 4, after Walcott,[1] showing a transverse section of *Calymene* in the thoracic region, it is seen that the membrane in the axis, or the mesosternite, is marked by four distinct lobes representing cross sections of longitudinal folds, and also that the legs are clearly attached at the sides. These folds can in no way be construed as proximal joints of legs. The gnathobases in *Calymene* are given

[1] Op. cit.

in sections, in fig. 3, pl. iii of Walcott's paper, and of *Ceraurus*, in fig. 2 of the same plate. During a recent visit to the Museum of Comparative Zoology, the writer examined many of the sections made by Walcott during his long and successful search for trilobite appendages. The structure shown in the figure here given (Fig. 4)

FIG. 4.—Transverse section through the thoracic region of *Calymene senaria*, Conrad; after Walcott; to show the folds of the ventral integument and the basal joints of the legs, with their points of attachment at the sides of the sternal arch. Enlarged three diameters.

was verified, and other sections were observed in which the folds were more pronounced, sometimes extending as thin laminæ into the body-cavity, thus having the character of a normal apodeme.

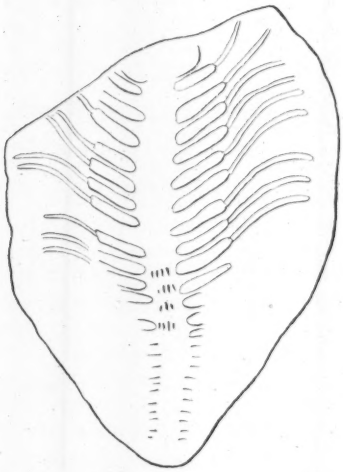

FIG. 5.—*Asaphus megistos*, Locke. A reduced outline of the figure published by Mickleborough; showing the endopodites in the pleural areas, with the gnathobases extending obliquely inward from the sides of the axis, and in the posterior thoracic median line the ridges or folds of the ventral integument. One-half natural size.

The second instance to be noted, where the ventral membrane has previously been illustrated, is a specimen of ***Asaphus megistos***, Locke, first described by Mickleborough [1] from the Cincinnati shales in Ohio. In his figure, an outline of which is here reproduced (Fig. 5), there are shown a number of discontinuous longitudinal lines in the axis of the posterior thoracic region. Mr. Charles

[1] Op. cit.

Schuchert has kindly examined the original specimen, now preserved in the United States National Museum, and writes that the longitudinal wrinkles in the axis are organic and not due to accident nor to tool-marks. In the best-preserved series "there are five longitudinal ridges, a central one with two on each side." They appear in cross section, as shown in the sketch furnished by Mr. Schuchert (Fig. 6).

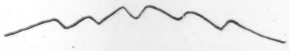

FIG. 6.— An enlarged profile of the mesosternal ridges of the preceding; from a sketch furnished the writer by Schuchert. The lower represents the ventral aspect.

The correct interpretation of this specimen, as illustrated by Mickleborough[1] and Walcott,[2] is: That the club-shaped bodies lying within the axis are the gnathobases attached at the sides of the axis; the curved members extending outward from the gnathobases are the endopodites; the longitudinal ridges in the ventral membrane between the inner ends of the gnathobases are the buttresses and apodemes of the mesosternites; the slender oblique rod-like bodies shown in the right pleural region in Walcott's figure are portions of the fringes of the exopodites.

The last specimen to be noted in this connection is the individual of *Ptychoparia striata*, already mentioned as described by Jaekel.[3] A reduced photographic reproduction of his figure (Fig. 7) is presented here for comparison with similar structures, as described in *Triarthrus*, *Calymene*, *Ceraurus*, and *Asaphus*. From the data here deduced, it would seem obvious that the specimen shows the imprint of the ventral integument in the axial region, the dorsal test and filling of the body-cavity having been removed. As in *Triarthrus*, the body has suffered collapse, thus bringing the dorsal and ventral walls quite near together. In the middle of each of the five or six anterior ventral arches is a groove left by the solution of the chitinous median apodeme, or buttress. On either side are two oblique grooves limiting two subangular areas, and outside of these are two other oblique grooves marking off sub-rhombic areas. The grooves in each case represent the cavities left by the removal of the chitinous thickenings of the membrane of the trilobite. Jaekel's attempt to remove the rock filling these areas naturally was ineffectual, since the latter represent the actual impression of the ventral integument. Were they simply the fillings of the hollow leg joints, as he claims, they should be readily detached from the matrix.

The foregoing descriptions and discussions of the character of the ventral integument in trilobites would have little or no scientific value, and would be about as useless as a minute analysis of the nodes and tubercles on the glabella of a *Phacops*, were it not for the fact that from them it is possible to reach some conclusions

[1] Op. cit. [2] Op. cit. [3] Op. cit.

regarding the myology of trilobites, and thus add something to the knowledge of their internal organization.

In the abdomen of a normal crustacean, as is well known, there is a pair of longitudinal dorsal muscles, the *extensors* of the abdomen. They divide into bundles, which are attached on the inner surfaces of the tergites of the somites. Likewise, on the ventral side, there is a larger pair of longitudinal muscles, the *flexors* of the abdomen, from which strands are given off and attached to each sternal arch.

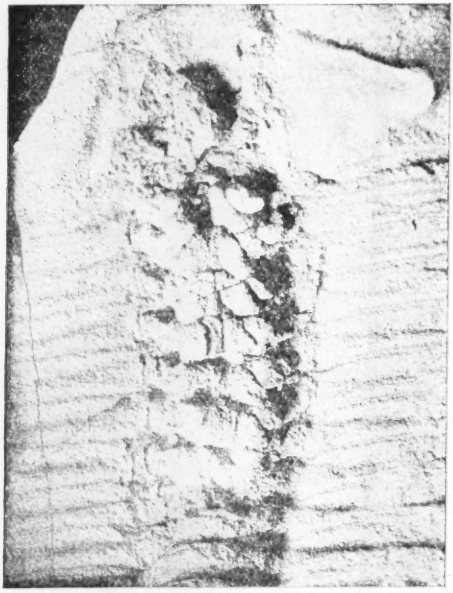

FIG. 7.—*Ptychoparia striata*, Emmr. Dorsal view of the anterior portion of a specimen preserved as a cast in sandstone, and enlarged about two diameters. In the glabellar and anterior thoracic region, the filling of the body-cavity has been removed from the axial region, thus exposing the imprint of the hypostoma and ventral integument with its buttresses, or apodemal structures. Reduced from the original figure published by Jaekel. Cambrian: Bohemia.

The strands from one somite unite with the main bundles within the cavity of the next anterior somite. In a diagrammatic form, this disposition of the ventral muscles is represented in the accompanying figure (Fig. 8).

Now, since in crustacea it is of very common occurrence to have chitinous extensions of the integument within the body-cavity either to divide or to support organs, as well as for the attachment of muscles, it seems a necessary conclusion to refer the thickenings and buttresses on the ventral membrane of trilobites to the same class of structures, which are usually termed apodemes. With this interpretation, the median longitudinal ridge on the mesosternite

of a trilobite would indicate the line of division between the two main ventral bundles. The first pair of oblique ridges on each side would delimit the main bundles and side strands, and show that these strands joined the main bundles obliquely within the cavity of the next anterior somite, as in ordinary crustacea. This accounts for the anterior truncation of the triangular area between the median and lateral ridges in the trilobite.

FIG. 8.—Diagram of the axial portions of three segments; showing the ventral abdominal muscles, the flexors, represented as two heavy longitudinal lines, together with the lateral strands attached to the sternal plate in each somite and continuing obliquely forward to their union with the main bundle in the cavity of the next anterior somite.

The nature of the outside pair of oblique ridges is not so plain. They may serve to divide the side ventral strands of the flexors from the bundle of muscles running from the proximal joints of the legs to the dorsal test, or they may simply mark the outside of the lateral strands.

The apodemes in general seem more strongly developed anteriorly in the thorax. Possibly, this condition may be explained on the basis that the ventral pair of the great flexor muscles received new strands at each segment from behind forward, so that near the cephalon they became large bundles for which progressively larger apodemes were formed.

It may be remarked, in conclusion, that a similar though apparently much simpler apodemal arrangement would be developed if the myology of the trilobites agreed with that of the theoretical crustacean ancestor, or that existing in some Isopods, Amphipods, etc., in which there are no large longitudinal bundles, but motion between the somites is effected by strands running from one segment to the next anterior. If viewed in this manner, there would necessarily be two median and two lateral strands. The previous explanation seems to be more in accordance with the structures actually seen in the trilobites, which in general possessed the power of enrolment to a high degree, and would be expected to have had a well-developed and efficient system of ventral muscles.

Summary.—The ventral integument in trilobites is a thin uncalcified membrane, which may be divided into pleurosternites and mesosternites, corresponding to the mesotergites and pleurotergites of the dorsal test, and like them connected segmentally by an interarticular membrane.

The mesosternites are usually marked by five longitudinal ridges, or buttresses, representing thickenings of the membrane, which may be homologized with apodemal structures in other crustacea, and not with the appendicular system.

These buttresses, or apodemes, include a single median one for each mesosternite, with two others on each side extending forward and obliquely inward, and enclosing sub-triangular or rhombic spaces.

The presence and disposition of these buttresses apparently afford information regarding the ventral myology of the trilobites. A pair of flexors is indicated, together with the lateral strands attached to each mesosternite and extending forward and inward to their union with the main bundles within the cavity of the next anterior somite.

EXPLANATION OF PLATES.

Plate IX. Triarthrus Becki, Green.

Fig. 1.—A specimen viewed from the dorsal side; showing the extent of the antennules and the limbs on the right side. Enlarged about three diameters.

Fig. 2.—The ventral side of a pygidium; showing at the left of the median line the form and disposition of the exopodites and endopodites. The conical ends of the joints of the endopodites are provided with bundles of stiff hairs. Owing to the concavity of the specimen, it is impossible to show it all in proper focus. Enlarged ten diameters.

Fig. 3.—The posterior portion of an individual viewed from the ventral side; showing the distal ends of the exopodites, with their setæ and long fringes. Enlarged nearly ten diameters.

Fig. 4.—Dorsal view of an individual; showing the nine pairs of anterior thoracic limbs fully extended on the left side. The jointed endopodites and fringed exopodites may be clearly differentiated. Enlarged about three diameters.

Fig. 5.—A still further enlargement of some of the limbs of the preceding specimen; showing in more detail the distinctive characters and arrangement of the exopodites and endopodites. Enlarged about ten diameters.

Utica Slate, Ordovician: near Rome, New York.

This plate of illustrations, although very inadequately representing the actual objects, is introduced mainly to show the exquisite character of preservation of the specimens of *Triarthrus*.

Plate X. Triarthrus Becki, Green.

Ventral view of an individual; showing the basal joints of the antennules, the biramous appendages, and the series of gnathobases. The appendages within the cephalon indicate their biramous structure like those over the thorax. They are therefore not simple as restored by Jaekel. The anal opening is shown near the extremity of the pygidium, but is obscure on account of not being in focus. Enlarged three and one-half diameters. (Original of fig. 1, pl. iv, vol. xv, American Geologist, 1895.)

Utica Slate, Ordovician: near Rome, New York.

Plate XI. Triarthrus Becki, Green.

The ventral side of an individual prepared to show the character of the endopodites of the entire thoracic series. The gnathobases are distinctly seen extending obliquely inward from the sides of the axis; then follow, within the pleurosternal region, the sub-triangular joints of the endopodites with more slender distal joints. The origin and course of the antennules at the sides of the hypostoma are also shown. In the middle of the axis of the mid-thoracic region the ventral membrane is exposed, and the transverse limitations of the sternal arches and interarticular membrane may be observed. The arches show the buttresses or ridges of apodemal nature, as described in the text. Enlarged three and one-half diameters.

Utica Slate, Ordovician: near Rome, New York.

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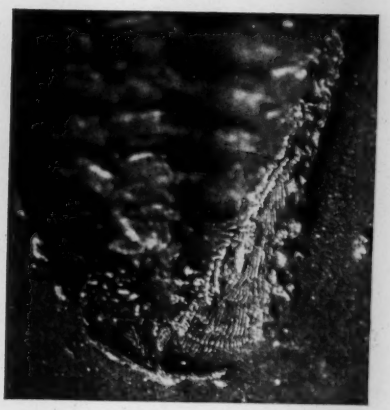

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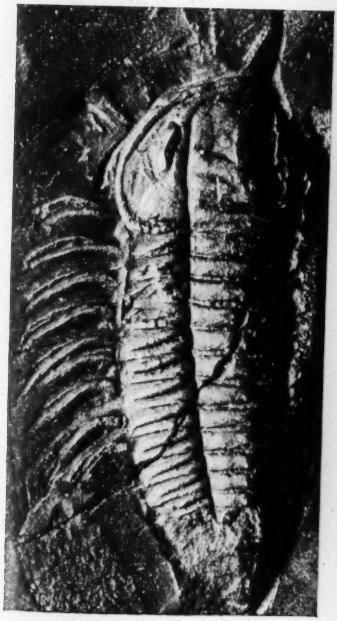
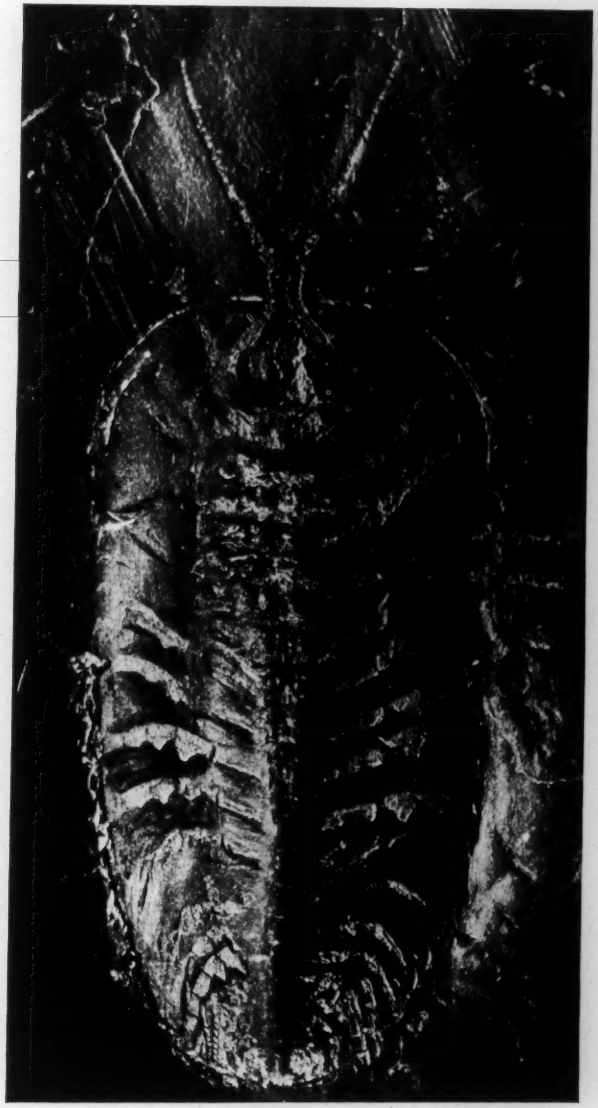


5

Appendages of *Trinucleus*

Ventral side of *Triarthrus*.



Ventral side of *Triarthrus*.

IV.—On the Correlation of the Palæozoic Rocks of South Africa.

By Walcot Gibson, B.Sc., F.G.S.

THE publication of the Annual Reports for 1898 and 1899 of the Cape Geological Commission, coupled with the recent account of the geology of the Transvaal Colony by Dr. Molengraaff, and of which a short abstract has appeared in this Magazine,[1] adds considerably to the knowledge of South African geology. The succession of the rock formations at the Cape has been constantly used as a basis of classification for the rock systems south of the Zambesi. In his recent paper Dr. Molengraaff correlates the formations of the Transvaal Colony with those met with in the south-eastern provinces of Cape Colony, and emphasizes the fact that the three stages of the Pretoria, Dolomite, and Black Reef series of the Transvaal Colony may be compared with the Witteberg, Bokkeveld, and Table Mountain Sandstone series of the Cape. It may therefore be of service to show on what grounds this supposed correlation is based. To do this the succession at the Cape of the formations below the Beaufort Beds in the typical region of the south-eastern province will first be given. The grouping adopted by the Cape Geological Commission[2] is in descending order of sequence as follows :—

Table of Strata below the Beaufort Beds of Cape Colony.

Ecca Beds	Sandstones and shales with *Gangamopteris*.
Dwyka Series	Conglomerates and interbedded plant-bearing shales. Included boulders of distant origin.
Witteberg Beds	Mainly quartzites. *Spirophyton*.
Bokkeveld Beds	Shales, sandstones, and greywackes. Fossils of a Devonian facies.
Table Mountain Sandstone	Sandstones and quartzites with occasional shales.
Great Unconformity.	
Malmesbury Beds	Non-fossiliferous slates, phyllites, mica-schists, and quartzites. Granite, quartz-porphyry, and diabase as intrusive rocks.

From the Table Mountain Sandstone upwards there is no break in the succession of these deposits, which are several thousand feet thick and have been traced successively along a length of outcrop extending for over 100 miles; on the other hand, the hiatus between the Table Mountain Sandstone and Malmesbury Beds is unequivocal.

The whole series, excepting on Table Mountain and near the coast, are thrown into complex folds, admirably displayed in the Hex River Mountains and Klein Zwartebergen. Instances of complete inversion are not infrequent, and are particularly apparent north of the Zwartebergen. It is to the south of this range, in the Cango district, that some deposits of slates, dolomitic limestones, and sheared conglomerates and grits are met with overlying the Table Mountain Sandstone, but brought into this position by

[1] Geol. Mag., Dec. IV, Vol. VIII (1901), pp. 475–8.
[2] Reports, 1897 et seq.

inversion. Their exact position in the sequence is somewhat doubtful, but in the account of the report for 1898 it would appear that these Cango rocks are to be regarded as being older than the Table Mountain Sandstone, but newer than the Malmesbury Beds. Mr. E. J. Dunn regarded them as the equivalents of his Namaqualand schists; that is, as belonging to a formation older than the Malmesbury schists. The task of unravelling the stratigraphy of this complicated region remains to be worked out when better maps are available. At present it is very unsatisfactory, especially when these Cango rocks appear to bear considerable resemblances to some of the deposits of the Transvaal Colony, which are considered by Dr. Molengraaff to be the equivalents of the Table Mountain Sandstone and Bokkeveld Beds.

Between the areas occupied by these older rocks in the southern provinces and the Prieska division (described in the report for 1899), south of the Orange River, a tract of country over 200 miles wide intervenes, of which the geology has not been reinvestigated. A large portion of this area is occupied by the Karroo formation, but the older rocks emerge from beneath it along the edges of the Karroo basin and have not yet been examined by the members of the Cape Geological Commission along their whole length. So far as Messrs. Rogers and Schwarz have examined the formations in the district of Prieska, they have determined the following descending sequence, naming the rock groups in accordance with the nomenclature adopted by Stow for the regions north of the Orange River in Griqualand West.

TABLE OF FORMATIONS IN THE PRIESKA DISTRICT.[1]

Glacial Conglomerate and Shales	A coarse conglomerate resembling a grunde moraine. Overlying shales, carbonaceous and thin-bedded.
	Great Unconformity.
Matsáp Series	Quartzites and grits with pebbles of jaspe rock. A sheared conglomerate at the base containing fragments of Griqua Town Series.
	Unconformity.
Griqua Town Series	Magnetic jasper rocks.
Campbell Rand Series	Limestones and quartzites.
Keis Series	Quartzites and mica-schists.

A granitic series is found in connection with the Keis group of rocks, but the relation of the two is uncertain. Messrs. Rogers and Schwarz state (p. 75 in report for 1899): "although the conclusion is mostly supported by negative evidence, it is probable that the whole granitic series was intruded among the Keis rocks, and that its gneissose structure was impressed upon it at the time when the dominant strike was given to the sedimentaries." The Campbell Rand and Griqua Town Series constitute a great mass of rocks, forming the Doornbergen and other areas in the district. Together with the Keis Series they appear to form an ascending sequence

[1] Report for 1899, Cape Geological Commission.

in the portion of the Doornbergen examined, but inversion due to overfolding occurs near Prieska Poort. The Matsáp Series are found lying in part unconformably on the dolomitic limestone and in part bounded by amygdaloidal lavas. The thickness of these beds is given by Messrs. Rogers and Schwarz,[1] as at least 3,000 feet, and the top is not seen.

The Glacial Conglomerate rests unconformably upon all the previous rocks. A description of this remarkable conglomerate has appeared elsewhere,[2] and need not be repeated. Stratification is generally absent and the boulders are of local origin; thus differing in a very marked manner from the Dwyka Conglomerate, with which, however, it seems to occupy a similar position in regard to the beds above, the conglomerate of both regions lying towards the base of the Ecca Series.

Such is the succession met with round Prieska. It is seen to differ materially from that of the southern provinces. Rocks resembling the Table Mountain Sandstone, Bokkeveld Beds, and Witteberg Series are absent, while the Glacial Conglomerate rests unconformably on a group of strata, of which the representatives may be found among the problematical rocks of the Cango district, and there only in a very imperfect degree.

In the south there is a great break between the Table Mountain Sandstone and Malmesbury Beds. Do these Prieska rocks bridge over the gap? It is interesting to find that the formations round Prieska have had intruded into them igneous rocks of pre-Karroo and post-Karroo ages. In all, Messrs. Rogers and Schwarz have detected five distinct types of igneous rocks, but their complete history has not been made out.

Considered as a whole, the geological record of the Palæozoic formations of Cape Colony as at present determined is very incomplete. Excepting the sequence from the Table Mountain Sandstone up into the Ecca in the south, the formations are met with only in fragments, and the data necessary to piece them together are wanting or remain to be discovered. It thus happens that the sequence of rocks in the south-east cannot be satisfactorily compared with that in the north-west.

It is a matter for regret that the relationships of the Cango deposits, Malmesbury schists, Table Mountain sandstones, and of the Prieska rocks, with their igneous history, have not yet been clearly determined. The Prieska rocks strike across the Orange River and are typically developed, judging from Stow's descriptions,[3] in Griqualand West, and with these the rocks above the famous 'Banket' formation of the Transvaal Colony have been compared.

[1] Report for 1899, p. 83.

[2] A. W. Rogers & E. H. L. Schwarz: Trans. Soc. Afr. Phil. Soc., vol. xi, pt. 2, pp. 113–120.

[3] Quart. Journ. Geol. Soc., vol. xxx (1874), pp. 581–680.

V.—A List of the 'Type,' Figured, and Described Fossils in the Norwich Castle Museum.

By Frank Leney, Assistant-Curator of Norwich Museum.

THE generic and specific names and the horizons are those given by the authors. The numbers in square brackets correspond to those of the Museum register. A list of references and a history of the collections is given at the end. The localities, except where otherwise stated, are in Norfolk.

MAMMALIA.

Alces (*Cervus*) *bovides*, Gunn MS. (E. T. Newton). Left frontal and antler. E. T. Newton, "Vert. Forest Bed" (1882), p. 52. "Memorials of John Gunn" (1891), p. 80, pl. i (Cervidæ), fig. A. Forest Bed: Norfolk Coast. Gurney Coll. [326]. *Type.*

—— Left frontal and antler. "Memorials of John Gunn" (1891), pp. 80, 81, pl. v (Cervidæ), fig. 2 (as H.). Forest Bed: Bacton. Gunn Coll. B. [327].

—— vide *A. latifrons* (Johnson) [322].

Alces Cromptoni, Gunn MS.; vide *Alces*, sp. [240].

Alces latifrons (Johnson). Cranial fragment. Boyd Dawkins, "Cervidæ" (Pal. Soc., 1887), p. 2, pl. i, fig. 2 [Kessingland *errore*]. "Memorials of John Gunn" (1891), pl. v (Cervidæ), fig. 1 (*A.* (*Cervus*) *bovides*, Gunn MS.). Forest Bed: Pakefield. Gunn Coll. 139 [322].

—— vide *Cervus latifrons*, Johnson [245].

Alces, sp. Right shed antler. "Memorials of John Gunn" (1891), pl. v (Cervidæ), fig. 4 (*A. Cromptoni*, Gunn MS.). Forest Bed: Trimmingham beach. Rev. J. Crompton [240].

—— Shed antler. Ibid., p. 83, pl. v (Cervidæ), fig. 5. Forest Bed: Pakefield beach. Gunn Coll. 135 [324].

—— Antler. Ibid., p. 82, pl. vi (Cervidæ), fig. 4. Horizon and locality unknown. Gunn Coll. F. [304].

Arvicola (*Evotomys*) *intermedius*, E. T. Newton. Right lower jaw. E. T. Newton, "Vert. Forest Bed" (1882), p. 85, pl. xiii, figs. 12*a*, *b*. Norwich Crag: Bramerton, Norwich. Reeve Coll. [524].

—— Lower left anterior cheek tooth. Ibid., p. 85, pl. xiii, fig. 13. Norwich Crag: Thorpe, Norwich. Fitch Coll. [551].

Balænoptera? sp. Vertebræ. Ibid., p. 108. Forest Bed: Bacton and Mundesley. Gunn Coll. [520, 522].

Bison bonasus, Linn., var. *priscus*, Boj. Horn-cores. E. T. Newton, Geol. Mag. [3], vol. vi (1889), p. 146. Forest Bed: Bacton and Happisburgh. Colman Coll. [482–486].

Cervus ardeus, C. & J. (Falconer MS.); vide *Cervus*, sp. [323].

Cervus bovides, Gunn MS. (E. T. N.); vide *Alces* (*Cervus*) *bovides* [326].

Cervus carnutorum, Laugel. Base of shed antler. Boyd Dawkins, Quart. Journ. Geol. Soc., vol. xxviii (1872), p. 409,

woodcut. Chillesford Beds: Aldeby, Suffolk. Rose Coll. [287].

Cervus Dawkinsi, E. T. Newton. Portion of antler. Boyd Dawkins, "Cervidæ" (Pal. Soc., 1887), p. 10. Forest Bed: Corton, Suffolk. Colman Coll. [329].

—— vide *C. Fitchii*, Gunn MS. [303].

Cervus Fitchii, Gunn MS. (E. T. Newton). Left shed antler. E. T. Newton, "Vert. Forest Bed" (1882), p. 56 [Bacton *errore*]. Boyd Dawkins, "Cervidæ" (Pal. Soc., 1887), pl. ii, fig. 2 (*C. Dawkinsi*, Newton). "Memorials of John Gunn" (1891), pl. vi (Cervidæ), fig. 1. Forest Bed: Mundesley. Fitch Coll. [303]. *Type.*

Cervus Flowerii, Gunn MS.; vide *Cervus*, sp. [501].

Cervus latifrons, Johnson. Left frontal and antler. Randall Johnson, Ann. Mag. Nat. Hist. [4], vol. xiii (1874), p. 2, pl. i. Boyd Dawkins, "Cervidæ" (Pal. Soc., 1887), p. 4, pl. i, fig. 6 (*Alces latifrons*). Forest Bed: Happisburgh. Colman Coll. [245]. *Type.*

Cervus polignacus, Robert. Portion of shed antler. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 479. E. T. Newton, "Vert. Pliocene Deposits" (1891), pl. iv, fig. 12. "Memorials of John Gunn" (1891), pl. i (Cervidæ), No. 94. Forest Bed: Mundesley. Gunn Coll. 94 [316].

—— Portion of antler. "Memorials of John Gunn" (1891), pl. ii (Cervidæ), No. 95. Forest Bed: Mundesley. Gunn Coll. 95 [317].

Cervus Savini, Dawkins. Base of left antler. Ibid., pl. vii (Cervidæ), fig. 4. Forest Bed: Kessingland. Gunn Coll. 515 [314].

—— Portion of antler. Ibid., pl. vi (Cervidæ), fig. 2. Forest Bed: Mundesley. Gunn Coll. 116 [319].

—— Beam of antler. Ibid., pl. vii (Cervidæ), fig. 5. Forest Bed: Norfolk coast. Gunn Coll. 524 [309].

—— vide *Cervus*, sp. [306].

Cervus Sedgwickii, Falconer. Right antler. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 472, pl. xxxvii, fig. 1 (*Eucladoceros*). "Memorials of John Gunn" (1891), pl. iii (Cervidæ), No. 99. Forest Bed: Bacton. Gunn Coll. 99 [243]. *Type.*

—— Bases of shed antlers. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 475, pl. xxxvii, figs. 2, 3. Forest Bed (?): dredged off Norfolk coast. Rev. W. Foulger [241, 242].

—— Fragment of antler. "Memorials of John Gunn" (1891), pl. iii (Cervidæ), No. 100. Forest Bed: Mundesley. Gunn Coll. 100 [307].

—— Portion of antler. H. B. Woodward, Proc. Geol. Soc., Aug. 1893, vol. xlix, p. 146. Norwich Crag: Bramerton, Norwich. R. W. Hinton, Esq. [315].

Cervus tarandus, Linn. Frontals and antlers. Owen, "Brit. Foss. Mamm." (1846), p. 479, fig. 197. Flower & Lydekker, "Mammalia" (1891), p. 325, fig. 131 (*Rangifer*). Geikie,

"Textbook of Geology" (1893), p. 1061, fig. 460. Bilney Moor, East Dereham. Rose Coll. [70].

Cervus verticornis, Dawkins. Left shed antler. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 479 (*Strongyloceros*). Boyd Dawkins, Quart. Journ. Geol. Soc., vol. xxviii (1872), p. 405, fig. 2. "Memorials of John Gunn" (1891), pl. ii (Cervidæ), No. 97. Forest Bed: Pakefield beach. Gunn Coll. 97 [305]. *Type.*

—— Right shed antler. "Memorials of John Gunn" (1891), pl. vii (Cervidæ), fig. 2. Forest Bed: Kessingland. Gunn Coll. 504 [325].

—— Portion of left shed antler. Boyd Dawkins, "Cervidæ" (Pal. Soc., 1887), p. 23, pl. v, figs. 1, 1*a*. Forest Bed: Corton, Suffolk. Colman Coll. [269].

—— Base of shed antler. "Memorials of John Gunn" (1891), pl. iii (Cervidæ), No. 107. Forest Bed: Mundesley. Gunn Coll. 107 [311].

—— vide *Cervus*, sp. [320].

Cervus, sp. Cranium and base of right antler. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 477, note 23. "Memorials of John Gunn" (1891), pl. iv (Cervidæ), No. 104 (*C. verticornis*). Forest Bed: Kessingland beach. Gunn Coll. 104 [320].

—— Cranium and bases of antlers. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 476, note 20. "Memorials of John Gunn" (1891), pl. iv (Cervidæ), No. 101. Forest Bed: Kessingland. Gunn Coll. 101 [321].

—— Cranium. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 476, note 21. "Memorials of John Gunn" (1891), pl. iv (Cervidæ), No. 102 (*C. Savini*). Forest Bed: Norfolk coast. Gunn Coll. 102 [306].

—— Left shed antler. "Memorials of John Gunn" (1891), pl. vi (Cervidæ), fig. 3. Forest Bed: Pakefield beach. Gunn Coll. E. [308].

—— Base of antler. Ibid., pl. vii (Cervidæ), fig. 3 (*C. Floweri*, Gunn MS.). Norwich Crag: Thorpe, Norwich. Gunn Coll. 501 [313].

—— Base of antler. Ibid., pl. iii (Cervidæ), No. 106. Forest Bed: Norfolk coast. Gunn Coll. 106 [318].

—— Fragment of antler. Ibid., pl. iii (Cervidæ), No. 98. Norwich Crag: Coltishall, Norwich. Gunn Coll. 98 [302].

—— Fragment of shed antler. Ibid., pl. ii (Cervidæ), No. 96. Norwich Crag: Horstead, Norwich. Gunn Coll. 96 [310].

—— Portion of antler. E. T. Newton, "Vert. Forest Bed" (1882), p. 63. "Memorials of John Gunn" (1891), pl. iii (Cervidæ), No. 105 (*C. ardeus*, Falc. MS.). Forest Bed: Mundesley. Gunn Coll. 105 [323].

Delphinus delphis, Linn. Vertebræ. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 79. Fluvio-marine Crag: Aldeby, Suffolk. Crowfoot and Dowson Coll. [507–511].

Elephas antiquus, Falc. Maxilla with molar teeth. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 182 [Ostend *errore*]. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1877), p. 39. Forest Bed: Happisburgh. Gunn Coll. 218 [1827].

—— Right upper molar. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1877), p. 32. Forest Bed: Bacton. Gurney Coll. 46 [1844].

—— Upper molar. "Memorials of John Gunn" (1891), pl. i, (Probos.), fig. F. Forest Bed: Happisburgh. Gunn Coll. 354 [1826].

—— Lower jaw. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 188. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1877), pp. 39, 55. "Memorials of John Gunn" (1891), pl. iii (Probos.), (prototype of *E. primigenius*). Forest Bed: Cromer Jetty. W. H. Windham, Esq. [1847].

—— Left ramus of mandible. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1877), pp. 39, 55. "Memorials of John Gunn" (1891), pl. iv (Probos.), No. 2 (*E. giganteus intermedius*). Forest Bed: Mundesley. Gunn Coll. 361 [1703].

—— Lower m.m. 2. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1877), p. 15. Forest Bed: Cromer. Fitch Coll. [1728, 1751].

—— Lower m.m. 3. Leith Adams, ibid., p. 18. Forest Bed: Norfolk coast. Gunn Coll. 304 [1970].

—— Right lower m. 3. Leith Adams, ibid., pp. 174–177, pl. xx, figs. 1, 2. "Memorials of John Gunn" (1891), p. 72 (*E. meridionalis*). Forest Bed: Corton, Suffolk. Colman Coll. [1788].

—— Lower m. 3 in jaw. Leith Adams, ibid., p. 39. Forest Bed: Overstrand. Gunn Coll. 306 [1754].

—— Lower m. 3. Leith Adams, ibid., p. 177. Forest Bed: Bacton. Gurney Coll. 19 [1786].

—— Molar tooth. Clement Reid, "Geology of Cromer" (1882), p. 119. "River Bed": Mundesley. Gunn Coll. [1971].

—— Molar tooth with glacial markings. "Witton, nr. Bacton, Norfolk." H. B. Woodward, Proc. Geol. Soc., Aug. 1893, vol. xlix, p. 146. Lower Boulder-clay: Sprowston, Norwich. J. Reeve, Esq. [1950].

—— vide *E. meridionalis*, Nesti [1835].

—— vide *E.* (*Loxodon*) *priscus*, Goldfuss [1832].

Elephas giganteus intermedius, Gunn; vide *E. antiquus*, Falc. [1703].

—— vide *E.* sp. [1765].

Elephas meridionalis, Nesti. Incisor tooth. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1881), pp. 9, 186. "Memorials of John Gunn" (1891), pp. 50, 70, 79, pl. v (Probos.), fig. 2. Forest Bed: East Runton. Sir T. F. Buxton, Bart., No. M. [1789].

lephas meridionalis, Nesti. Incisor tooth. Leith Adams, ibid., p. 186. "Memorials of John Gunn" (1891), p. 79. Dredged off Corton, Suffolk. Colman Coll. [1871].

—— Incisor of young animal. Leith Adams, ibid., p. 198. "Memorials of John Gunn" (1891), pp. 49, 78, pl. v (Probos.), fig. 1. Forest Bed: Bacton. Gunn Coll. 302 [1790].

—— Lower jaw. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 140. Leith Adams, ibid., p. 201. Forest Bed: Mundesley Cliff. R. Barclay, Esq. [1767].

—— Right ramus of mandible. Leith Adams, ibid., p. 201 [368 *errore*]. "Memorials of John Gunn" (1891), p. 71. Forest Bed: Norfolk coast. Gunn Coll. 367 [1732].

—— Right ramus of mandible. Falconer, "Pal. Memoirs" (1868), vol. ii, pp. 132, 140. Leith Adams, ibid., p. 199, pl. xxii, fig. 2. "Memorials of John Gunn" (1891), pp. 70, 71, 74, pl. iv (Probos.), fig. 1. Forest Bed: Bacton. Gunn Coll. 215 [1702].

—— Right ramus of mandible. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 132. Leith Adams, ibid., p. 201. "Memorials of John Gunn" (1891), p. 70. Forest Bed: Bacton. Gunn Coll. 215*a* [1694].

—— Left lower m.m. 2. Leith Adams, ibid., p. 188, pl. xxii, figs. 3, 3*a*. Forest Bed: Mundesley. Gunn Coll. 214 [1837].

—— Germ of m.m. 2. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 1, 1*a* [No. 11 *errore*], and "Pal. Memoirs" (1868), vol. i, p. 443; vol. ii, p. 133. Leith Adams, ibid., p. 188. Forest Bed: Norfolk coast. S. Woodward Coll. 4 [1784].

—— Lower m.m. 2. Leith Adams, ibid., p. 188. "Fresh-water deposits": Mundesley. Fitch Coll. [1750].

—— Right lower m.m. 2. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 3, 3*a*, and "Pal. Memoirs" (1868), vol. i, p. 444; vol. ii, p. 134. Leith Adams, ibid., p. 188. Forest Bed (?): Norfolk coast. S. Woodward Coll. 6 [1779].

—— Left lower m.m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 4, 4*a*, and "Pal. Memoirs" (1868), vol. i, p. 444; vol. ii, p. 134. Leith Adams, ibid., p. 189. Forest Bed: Norfolk coast. S. Woodward Coll. 10 [1785].

—— Left upper m. 1. Leith Adams, ibid., p. 192, pl. xxii, fig. 1. Forest Bed: Cromer. Fitch Coll. [1955].

—— Right and left upper m. 3. Leith Adams, ibid., p. 198. Forest Bed: Cromer beach. Gunn Coll. 219 [1699].

—— Left upper m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 14, 14*a* [No. 10 *errore*], and "Pal. Memoirs" (1868), vol. i, p. 447; vol. ii, p. 137, pl. viii, fig. 4. Leith Adams, ibid., p. 195. Forest Bed: Norfolk coast. S. Woodward Coll. 10*a* [1755].

Elephas meridionalis, Nesti. Portion of upper m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 15, 15*a* [No. 13 *errore*], and "Pal. Memoirs" (1868), vol. i, p. 447; vol. ii, p. 138. Leith Adams, ibid., p. 195. Forest Bed: Happisburgh. Old Coll. 13*a* [1772].

—— Portion of upper m. 3. Leith Adams, ibid., p. 198. Forest Bed: Norfolk coast. Gunn Coll. 220 [1763].

—— Upper m. 3. Leith Adams, ibid., p. 198. "Memorials of John Gunn" (1891), pl. i (Probos.), fig. H (prototype of *E. primigenius*). Forest Bed (?): Norfolk coast. Gunn Coll. 223 [1696].

—— Upper m. 3. Leith Adams, ibid., p. 198. "Memorials of John Gunn" (1891), p. 50, pl. i (Probos.), fig. D. Forest Bed: Bacton. Gunn Coll. 330 [1742].

—— Right upper molar. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, fig. 16, and "Pal. Memoirs" (1868), vol. i, p. 447; vol. ii, pp. 138, 182 (*E. antiquus*). Leith Adams, ibid., p. 39 (*E. antiquus*). Forest Bed: Happisburgh. S. Woodward Coll. 55 [1835].

—— Left upper molar. Leith Adams, ibid., p. 189. Forest Bed: Bacton. Gurney Coll. 9 [1777].

—— Abnormal left upper molar. "Memorials of John Gunn" (1891), p. 69. Norwich Crag: Horstead, Norwich. Gunn Coll. 334 [1574].

—— Left lower m. 1. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 5, 5*a*, and "Pal. Memoirs" (1868), vol. i, p. 445; vol. ii, p. 134. Leith Adams, ibid., p. 191. Forest Bed: Mundesley. S. Woodward Coll. 8 [1729].

—— Left lower m. 1. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 6, 6*a*, and "Pal. Memoirs" (1868), vol. i, p. 445; vol. ii, p. 135. Leith Adams, ibid., p. 191. Forest Bed: Mundesley. S. Woodward Coll. 7 [1723].

—— Left lower m. 2. Leith Adams, ibid., p. 198. Forest Bed: Mundesley. Gunn Coll. 311 [1693].

—— Right lower m. 2. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 7, 7*a*, and "Pal. Memoirs" (1868), vol. i, p. 445; vol. ii, p. 135. Forest Bed: Norfolk coast. S. Woodward Coll. 13 [1834].

—— m. 2. Leith Adams, ibid., p. 193. Forest Bed: Bacton. Gurney Coll. 22 [1769].

—— Right lower m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 18, 18*a*, and "Pal. Memoirs" (1868), vol. i, p. 448; vol. ii, p. 130, pl. viii, fig. 1. Leith Adams, ibid., p. 196. "Mammaliferous Crag": Thorpe Road, Norwich. S. Woodward Coll. [1570].

—— Right lower m. 3. Leith Adams, ibid., p. 197. Forest Bed: Bacton. Gurney Coll. 21 [1774].

(*To be continued.*)

NOTICES OF MEMOIRS

I.—Additional Notes on the Cambrian of Cape Breton, with Descriptions of New Species. By G. F. Matthew, LL.D., F.R.S.C. (From Bulletin of the Natural History Society of New Brunswick, Canada, No. xx, vol. iv, pt. 5.)

THIS article deals with two subjects: (A) New Species of the Etcheminian or Basal Cambrian; (B) The Tremadoc Fauna. Under the first the development of the three perforate genera *Acrothyra*, *Acrotreta*, and *Acrothele* is described. The two first have been found in the lowest fossiliferous beds of the Basal Cambrian; from which they are traced upward, the first to *Protolenus* fauna (under *Paradoxides*), the second into the Ordovician. The first genus is specially prevalent in the Etcheminian or Basal Cambrian beds, one species being found in the Lower and another in the Upper Etcheminian beds.

A point worked out in this article is the change in size and form of *Acrotreta* as time went on. The first species known were about twice as wide as high, but towards the close of the lifetime of the genus the height and width were about equal, though in two species the height exceeded the width.

Acrothele was not found in the Lower Etcheminian, but comes in with the Upper Etcheminian fauna. Various species are quoted, ranging from this fauna to the top of the Cambrian.

There are described in this paper, of *Acrothyra* one new species and six mutations; of *Acrotreta*, one new species and two mutations; of *Acrothele*, two new species and one mutation.

The second part of the paper relates to species of Gasteropods and Trilobites recognized as representatives of the Tremadoc Fauna. *Asaphellus Homfrayi* is cited, also a new species, *A.* (?) *planus*. Species of *Triarthrus*, *Parabolinella*, and *Bellerophon* were found, also *Lingulella* and *Acrotreta*.

Six plates of figures are given to show the forms and characters of new species described.

II.—On the Relation of the Silurian and Ordovician Rocks of North-West Ireland to the Great Metamorphic Series. By Jas. R. Kilroe and Alex. McHenry.[1]

UPPER Silurian rocks, as high as Wenlock, have been metamorphosed along the Croagh Patrick range, which led to their inclusion in the great metamorphic group when the ground was originally mapped. The corresponding rocks of Wenlock age on the south margin of the Mayo and Galway Silurian basin, near Killary Harbour, are not metamorphosed, and rest unconformably upon the metamorphic group.

This stratigraphical break has for many years been supposed to form an insuperable objection to the acceptance of Murchison's

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

conjecture that the metamorphic rocks of Galway, Mayo, etc., are altered representatives of the Lower Silurian or Ordovician rocks. This, however, is not an obstacle, for a break, accompanied by overfolding and possibly metamorphism of Lower Silurian strata, has been proved to have occurred in Llandovery times, which admitted of Wenlock or possibly Tarannon beds being unconformable to unmetamorphosed Lower Silurian as well as to the metamorphic group. All this happened prior to a second violent disturbance and overfolding which accompanied the metamorphism of Wenlock strata already mentioned, and which occurred in Ludlow times.

A comparison of the Lower Silurian series in the west of Ireland with the metamorphic group of the same region and Donegal, shows so strong a resemblance between them—as regards the lithological characters of individual members in their original form, their order of succession, and certain peculiar coincidences of associated sedimentary components, described in detail in the paper—that it forms a creditable *primâ facie* argument for their correlation.

One instance may here be mentioned. At Westport and Achill Beg thick bands of fine conglomerate, associated with black slate, occur as an integral part of the metamorphic group, while on the south shore of Clew Bay thick bands of fine conglomerate—very similar in character to those in Achill Beg—occur in association with black slate, which, though sufficiently crushed to justify their inclusion by the original surveyors in the metamorphic ground, are now known to be of Lower Silurian age, identical with rocks of this age in Clare Island.

The chief objection to ascribing the metamorphic rocks of Mayo and Galway to the Lower Silurian age has been the present difference of condition between them and the fossil-bearing Lower Silurian rocks of the adjoining area. This difference seems to us explicable by conceiving that the great dislocation which occurred in Llandovery times, and occasioned an inversion of strata by overfolding at Salrock between the Killaries, carried unmetamorphosed Lower Silurian rocks about Leenane against and over rocks of, say, the same age, near Leenane, which had undergone metamorphism in connection with granitic intrusions. These may be seen in the vicinity of Kylemore. Unfortunately the great zone of break is now concealed by newer strata, and further is obscured and complicated by post-Ludlow faults.

III.—The *Glossopteris* Flora of Australia. By E. A. N. Arber, B.A., Trinity College, Cambridge.[1]

THE *Glossopteris* flora is one of the most remarkable and widely distributed of fossil floras. Typical members, such as the fern-like plants *Glossopteris* and *Gangamopteris*, with the Equisetalean genus *Phyllotheca*, occur in rocks of Permo-Carboniferous age in India, Australia, South Africa, and South America, pointing to the

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901. See also Geol. Mag., Dec., 1901, p. 573.

former existence of a southern continent whose flora was for the most part distinct from that of the same age in Europe and North America.

In the Newcastle beds of New South Wales all the typical members of the flora occur without any admixture of northern types (e.g. *Lepidodendron* and *Sigillaria*), as has been recorded from similar beds in South Africa and South America. The flora of the Newcastle rocks is interesting botanically both on account of the wide distribution of the chief members, which show points of identity and unity in type with those of the Lower Gondwana of India and the Permian of Russia, and also from the morphological characters presented by many of the plants themselves. The collection which forms the subject of these remarks is in the Geological Museum, Cambridge, and is noteworthy as being one of the earliest (1839–44) formed of fossil plants from the continent of Australia.

REVIEWS.

I.—History of Geology and Palæontology to the End of the Nineteenth Century. By Professor Karl Alfred von Zittel. Translated by Maria M. Ogilvie-Gordon, D.Sc., Ph.D. 8vo; pp. 13, 562. (London: Walter Scott, 1901. Price 6*s*.)

THOSE who are not familiar with the German language will be grateful to Mrs. Ogilvie-Gordon for this translation of von Zittel's comprehensive and most interesting History of Geology, which was published two years ago. In the present work the text of the original has been curtailed by the omission of a chapter on Topographical Geology, and in a few places the subject-matter has been amplified—the changes being made with the author's approval.

Geology is rightly regarded as a modern science, for prior to the days of Hutton and William Smith there were no established principles for the interpretation of the facts. Nevertheless, we know that from the earliest days of which records are preserved, curiosity and interest were manifested in the rocks and stones that form the solid earth; and, while there were many shrewd guesses about former extensions of the sea and other physical changes, the observations were disconnected and the hypotheses for the most part were fanciful. Aristotle and Seneca in the earlier times; Leonardo da Vinci, George Bauer (Agricola), and Conrad Gesner prior to the seventeenth century, are among those whose views command most respect and admiration: but every philosopher who dealt with the origin or history of the earth appears to be mentioned by von Zittel. If we marvel at the erudition which has enabled the author to deal with these old writers and to point out so clearly the chief part which each has taken in the advancement of sound knowledge, we marvel still more when we come to later times with its multitude of workers and of books and papers, and find the same exhaustive treatment of the subject, with references necessarily brief,

but yet clear, instructive, and impartial. While we may agree with the author that "With specialisation in geology and palæontology, the spring-time of the science was over," we must differ from him when he says, "The period was past when a man could mentally survey the whole field," for this is what he has done.

In his introduction the author deals with the *First Period*, or geological knowledge in the ages of antiquity; with the *Second Period*, or beginnings of palæontology and geology; with the *Third Period*, or heroic age of geology, 1790–1820; and more briefly with the *Fourth Period*, or modern geology. In the following six chapters the progress in various branches of geology is discussed, and there the labours of the heroes and all later workers are as fully acknowledged as possible. It is not a work, however, of which a summary can be given. It is itself a summary. Works of all kinds that have aided the progress of science are dealt with. Thus a considerable space is rightly given to Lyell's works and to the history of them, and reference is made to De la Beche's *Geological Observer*, "which is full of new observations and facts." In this connection we miss only the name of John Morris, whose Catalogue of British Fossils was surely worthy of mention.

In the references, however brief, there is generally some useful criticism or information; thus we read: "Following Rütimeyer's method, W. Morris Davis depicted the different stages in the development of a valley"; or again, "After Suess and Hyatt had opened the gates for the creation of new generic names, the palæontological literature of the Cephalopoda was inundated by innumerable new genera and species, most of them only narrowly defined."

A work so full of information, historical, geological, and even biographical, is unquestionably one which should be kept for reference by every geological worker. The translator has given thirteen portraits, including the author, von Buch, Cuvier, Murchison, Lyell, Owen, von Richthofen, Agassiz, and Suess; and we may heartily congratulate her on the production of a volume which, while it adds to the interest of geology, cannot fail to assist in the advancement of the science. H. B. W.

II.—The Foraminifera: an Introduction to the Study of the Protozoa. By Frederick Chapman, A.L.S., F.R.M.S., Palæontologist to the National Museum, Melbourne. 4to (28 × 18 cm.); pp. xvi, 354, with 15 Plates and 42 Figures. (London: Longmans & Co., Feb. 1902. Price 9*s.* nett.)

THANKS to Frederick Chapman, who has devoted so many years to the study of fossil and recent Foraminifera, and the rocks largely built up of them, we have now a volume dealing with the general subject. Of its usefulness there can be no possible doubt, for up to the present one has had to search for a special point through very nearly 4,000 tracts and separate publications. In this volume Mr. Chapman has digested all these various works into readable and accessible form, and rearranged the principal items

of Sherborn and Tutkowski's Bibliographies under subjects, e.g., biology, shell morphology, classifications, technical, genera or special groups, special geological faunas, and recent faunas.

Starting with introductory remarks on the nature and occurrence of Foraminifera, their importance to the zoologist and geologist, structure, classification, and position of the group, he next deals with the shell-structure, reproduction, and plan of growth, gives a general sketch of the ideas of the early authors, and then devotes a chapter to each family. The various genera are defined, and a specific example is quoted and figured in outline; the geological range of the genus is given, and some general remarks accompany the species. It would have been useful if Mr. Chapman had always noted the original type-species of the genus, as well as what in his opinion is the typical form. But nowadays, there are many who regard an original type as of mere archæological interest, and those curious on either side can easily find out for themselves.

Following on with the geological range of the Foraminifera, we find an interesting sketch of this part of the subject, in which Mr. Chapman dismisses the useful Eozoön, the supposed organic origin of which gave rise to so much valuable research in microscopy, and casts well-founded doubts on the supposed pre-Cambrian bodies described as Foraminifera by Cayeux. Coming to Cambrian times, Chapman recalls many finds in beds of this age, both at home and abroad, and from that period onwards the Foraminifera have been rock-builders on a large, sometimes a gigantic scale. One need only instance the *Saccammina* and *Fusulina* Limestones of Carboniferous times, and the Nummulitic, Orbitoidal, and Alveolina Limestones of the Tertiary period.

Chapter xviii deals with the "geographical distribution, with remarks on the accompanying conditions of temperature, depth, and general environment," in which the various oceanic deposits are discussed. And chapter xix treats of the "collection, examination, and mounting of Foraminifera." The bibliography of subjects, concluding the volume, we have already alluded to.

The book is illustrated by fifteen plates, fourteen of which contain outline sketches of the typical forms of the various genera, and the odd one is a view of Dog's Bay, Galway, from one of Mr. Welch's well-known photographs. The outline sketches are, on the whole, sufficient for the purpose required, most of them being exceedingly characteristic. Forty-two other illustrations are given in the text, many of them being original; these include rock-sections, structures, apparatus, etc., and considerably enhance the value of the book. The author's style is clear and concise, and the descriptions of the genera give in as few words as possible just what is wanted. The book will find ready acceptance from a large body of students, and Mr. Chapman may be congratulated on opening his colonial career so auspiciously. The dedication to Professor Rupert Jones is particularly happy, and there is a pleasing reference to Professor Judd, whose laboratory afforded the author rich opportunities for work on this group of animals for many years. C. D. S.

III.—Igneous Complex of Magnet Cove, Arkansas. By Henry S. Washington. Bull. Geol. Soc. Amer., vol. xi, pp. 389–416; 1900.

The Foyaite-Ijolite Series of Magnet Cove: A Chemical Study in Differentiation. By Henry S. Washington. Journ. Geol., vol. ix, pp. 607–622, 645–670; 1901.

THE great variety of igneous rocks, particularly of types rich in alkalies, developed at numerous centres in the eastern half of the North American continent, promise to yield many results of more than local interest to the petrologist, and Dr. Washington has now been engaged for some years in the study of certain important districts. From Essex County, Massachusetts, he has passed to the no less interesting area of Magnet Cove, Arkansas, originally described by the late J. F. Williams; and the results of his work are embodied in the two papers cited above. They include, firstly, an attempt to decipher the form and geological relations of the intrusive bodies, a matter of some difficulty owing to the poorness of the exposures; secondly, a re-examination of the rocks themselves, including a number of new chemical analyses, with calculations of the percentage mineral compositions and comparison with known types from other districts; and, finally, a chemical study of the principal rock-types as a natural group, with reference to their common origin by magmatic differentiation.

The outcrops of the chief igneous rocks of the Cove occupy an elliptic area, and divide, as shown on Williams' map, into an inner ellipse, composed of the most basic rocks, and an outer elliptic ring, consisting of rocks on the whole less basic and separated from the former by a ring of metamorphosed sediments. Williams believed the outer ring of igneous rocks to be of distinct origin from the inner body and of decidedly posterior intrusion, but Washington considers the whole to form a single group with intimate genetic relationship. The latter author, indeed, makes the outer ring continuous underground with the inner mass, the intervening metamorphosed sediments resting on the igneous rocks and representing the relics of what was once the cover of a single laccolitic intrusion. The argument here is scarcely convincing: although the metamorphosed rocks form a broken ridge, the area is not one of high relief, and it is noteworthy that none of the igneous rocks belonging to the outer ring are found, even as outliers, in the inner part of the Cove. Disregarding the metamorphosed rocks of the ridge, the various types met with are arranged roughly in concentric zones of decreasing basicity from centre to margin. Assuming the centre of the exposed surface to represent the centre of the laccolite, Washington points out that this disposition of the various rocks is the reverse of that described in some other igneous complexes, where the most basic type occupies the outermost ring. This evidently depends upon the interpretation adopted of the general structure of the mass, and an alternative reading of the observations does not seem to be excluded. The arrangement is apparently that of a dome. If we suppose the igneous rocks to have been

themselves affected in some measure by the central uplift, we may perhaps plausibly picture the whole as consisting of two thin laccolites bent into a gentle dome and exposed by erosion which, in the centre of the area, has almost penetrated to the underlying sedimentaries. In this view the central exposure of rock would represent, not the centre, but the base of the lower laccolite; and the successive rings would represent, not inner and outer zones, but lower and higher strata.

Washington's petrographical investigation is of great value as defining with precision the several rock-types recognized by Williams. The outermost member of the complex is a *foyaite*, consisting of orthoclase (51·8 per cent.), nepheline (20·3), canerinite, pyroxenes, etc. Next comes the rock for which the term *covite* is adopted: it has points of resemblance with the shonkinites of Montana, and may indeed be regarded as a nepheline-shonkinite. Here felspars (orthoclase and albite) still make up more than half of the mass; nepheline is reduced to 9 per cent., and the principal ferro-magnesian element is hornblende. In the third place comes the very interesting rock in which Williams described the now well-known pseudomorphs after leucite. This mineral is calculated to have made up 36·9 per cent. of the rock, nepheline being 25·5, orthoclase only 3·9, and the rest melanite and pyroxenes. This rock, which Washington names *arkite*, is, as Mr. Teall[1] has pointed out, almost identical with the borolanite of Sutherland, although the Arkansas type must have been richer in nepheline.

The three rocks enumerated, which make up the outer ring, are leucocratic (the white minerals predominating). The types met with in the inner part of the Cove are melanocratic (with preponderant dark minerals), and here felspar almost wholly disappears in favour of nepheline. The *ijolite* contains 38·7 per cent. of that mineral, a smaller proportion than in the typical ijolite of Finland; of the rest, pyroxenes make 42·8 per cent. and melanite 15·3. Another distinct type is recognized under the name *biotite-ijolite*. This carries nepheline 24·1 per cent. and orthoclase 4·8, the rest being diopside, melanite, and other dark minerals. Finally, there is a *jacupirangite* identical with the type-rock from Brazil; this has only 4 per cent. of nepheline, the remainder being chiefly pyroxene. This rock is not found (may possibly be concealed) in the centre of the area, where it should be expected, but is described from an outlying locality. The centre, however, is occupied by a mass essentially of magnetite, which produces great disturbance of the compass in its neighbourhood. The mineralogical, no less than the chemical, composition of the rocks indicates a very close consanguinity for the whole assemblage; but one may remark certain differences, especially in the ferro-magnesian silicates of the several types, which militate to some extent against the hypothesis of their origin by diffentiation *in sitû*.

In his general discussion of the mutual relationships of all these associated rocks the author is necessarily upon less firm ground:

[1] Geol. Mag., 1900, p. 389.

but he offers some suggestive considerations, and presents them with considerable originality of method. In setting forth the variations in chemical composition in the series he makes use of the graphical method, which, though it cannot of course lead to any result not contained in the columns of figures, will often bring out points which might otherwise escape notice. The abscissæ in his diagrams represent the radial distance of the several rocks from the centre or 'epicentre' of the complex, and it is considered that this expresses best the essential relations. The *a priori* objection to taking the silica for the abscissæ seems, however, to be without much force. As in many other cases, the order of increasing silica-percentage is manifestly the natural order in which to consider the several rocks (in this case corresponding with their disposition in space); if we arrange them in order of their content (say) of potash or soda, the whole is thrown into confusion. This, even apart from other considerations, places silica on a different footing from the other oxides. The choice of 'independent variable' cannot affect any very essential relations of the series. If, for instance, the silica and other oxides were all linear functions of some arbitrary variable, the other oxides would necessarily be linear functions of the silica. Washington's method, however, adapts itself well to the special case of differentiation in place with symmetrical arrangement.

It is to differentiation *in place* of a presumably homogeneous magma that the author ascribes this complex, notwithstanding the fact that the several rock-types are sharply separated from each other with little or no indication of transition. Taking into account the volume of each rock in the complex, he calculates the composition of the hypothetical initial magma, and finds that it does not agree at all closely with any member of the series. This result connects itself with the fact that the lines in the diagram of variation are not straight, or, in other words, the series is not a 'linear' one. Leaving out of account one rock, the covite, the lines are all smooth curves. The silica-line is inflected, being nearly horizontal in the middle part of the diagram, but descending gently towards the basic end and ascending rather steeply towards the acid end. The curves for alumina and the alkalies ascend gently and steadily, being only slightly curved. The curves for iron, magnesia, and lime, on the other hand, descend, and are decidedly convex upward. Covite does not fit into this comparatively simple scheme of variation, and the author regards it as probably originating by a *secondary* differentitaion, most likely from the foyaite magma. He attempts, indeed, to discover the complementary (more leucocratic) product, which may be represented by a variety of the foyaite. This latter rock, like the jacupirangite, has not been found in the place required by theory, and these irregularities, together with the generally sharp delimitation of the several concentric zones and certain points in the mineralogical constitution of the rocks, suggest to a critic that the differentiation may have been effected, at least in the main, prior to intrusion. In whichever way this minor question may be

ultimately decided, the intimate genetic relationship connecting the several members of the series cannot be doubted, and this foyaite-ijolite complex affords one more illustration of a number of very different rock-types derived from a common source and disposed in a regular order. A. H.

IV.—Mémoire sur l'Histoire Géologique du Graphite. By Professor E. Weinschenck. Compte Rendu VIII Congrès Geol. Internat. Paris (1901).

GRAPHITE, graphitite, and graphitoid are varietal names for one mineral, graphite, based on subordinate characters such as lustre, fracture, and compactness. The principal known occurrences of graphite are reviewed. In *Ceylon* the graphite occurs in veins traversing the (intrusive) granulites, which show contact alteration in a very narrow zone immediately next to the veins. In this zone the felspars are altered to kaolin and nontronite (a hydrous ferric silicate), and flakes of graphite, needles of rutile, and individuals of sphene appear. At *Passau* in Bavaria the graphite occurs in lenticular masses and nests in gneissic rock of somewhat shattered character; but this rock is only charged with graphite when in contact with a neighbouring granite massif. The felspars are altered to kaolin and nontronite, and the graphite is accompanied by rutile. It is not a primary constituent of the gneiss, the flakes occurring always in the fissures and joints of the rock, which have, of course, originated since its crystallization.

The graphite of the Böhmerwald occurs in an essentially similar way, portions of gneiss rich in graphite having, however, a rather more stratified character, related to that of the beds of limestone present in the gneiss. The graphitic rocks are profoundly altered as at Passau, but are not clearly associated with a large mass of granite, although there are small bosses and dykes of granitic rock following the direction of the graphitic bands.

The occurrences of graphite in Cumberland and at Batongol in Siberia are referred to; the former occurs in association with an eruptive 'greenstone porphyry,' the latter in connection with a nepheline syenite. These two sources of graphite are no longer worked.

The alteration and impregnation products of the graphitic rocks are thus similar in Passau, Bohemia, and Ceylon. In Bohemia and Passau manganese peroxide is also abundant. So that the chemical processes must have been the same or similar in each case.

We might at first suppose that the hot magma in its ascent had distilled and volatilized large masses of organic matter, producing crystallized graphite. This would have liberated hydrogen and other reducing agents; instead we actually find that highly oxidized minerals accompany the graphite. More likely the penetration of carbon-bearing emanations or solutions is one of those post-volcanic phenomena which may follow the intrusion of igneous rocks. The metal-carbonyls — not yet met with in nature, however — easily decompose to metallic oxides and graphite with loss of CO_2. Professor

Weinschenck thinks that a reaction of this kind would explain all the peculiar characters of the graphite occurrences; the great alteration of the rocks is due to the quantity of CO_2 liberated, and the abundance of peroxides of heavy metals replacing silicates originally poor in them is also explained.

The common association of rutile with graphite may indicate the presence of cyanogen, which readily forms with titanium volatile combinations; the existence of nitrogen in the Ceylon graphite perhaps points in the same direction.

Passing to the Alpine localities (Styrian and Cottian Alps), we find that graphite occurs in beds of Carboniferous age where it is certainly of organic origin. It is usual to regard any metamorphic action in the Alpine regions—such as here the alteration of coal to graphite—as the result of dynamo-metamorphism. But the vegetable remains in the Styrian shales are not deformed, nor do the quartzites in the Cottian Alps show traces of crushing or brecciation. It is to a foliated gneiss (a foliated variety of the Central Alpine granites) associated with the altered Carboniferous beds that we must attribute the modifications met with in the Carboniferous sediments, by which the shales have been changed to chloritoid phyllites, the sandstones to quartzites, the coal to graphite.

So that when we review the chief localities for graphite we are struck with the fact that there is never a gradual passage from coal to graphite on the lines of regional metamorphism, but that when graphite is formed from coal it is a contact mineral. Graphite is not the final term of a series of carbonaceous rocks beginning with lignite and ending with anthracite.

Professor Weinschenck's researches show that the origin of graphite is different in different cases. It is clear, however, that in none of the above localities—and they are the most important known—is the graphite to be regarded as the representative of an ancient coal, *older than any rocks containing determinable fossils.* On the contrary, *graphite is usually an igneous emanation-product*; when of organic origin it occurs as a contact mineral in rocks much younger than the oldest fossiliferous strata. So that *the presence of graphite in ancient rocks does not push back the origin of life beyond the point at which we meet with the oldest authentic fossils.*

A. K. C.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—February 21st, 1902.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

Annual General Meeting.

The reports of the Council and of the Library and Museum Committee for the year 1901, proofs of which had been previously distributed to the Fellows, were read. In the first place a reference

was made to the Address presented to His Majesty the King on the occasion of the death of Queen Victoria. After premising that the financial prosperity of the Society was again a matter for congratulation, the Council stated that the number of Fellows had undergone scarcely any change during 1901. The number elected was 52 (7 less than in 1900), of whom 34 qualified before the end of the year, making, with 17 previously elected Fellows, a total accession of 51 in the course of the twelve months under review. During the same period, the losses by death, resignation, and removal amounted to 55, the actual decrease in the number of Fellows being therefore 4 (as compared with a decrease of 10 in 1900).

The total number of Fellows, Foreign Members, and Foreign Correspondents, which on December 31st, 1900, was 1,334, had decreased to 1,329 by the end of 1901.

The balance-sheet for the year 1901 showed receipts to the amount of £3,503 17*s.* 8*d.* (including a balance of £388 14*s.* 10*d.* brought forward from the previous year), and an expenditure of £3,100 5*s.* 5*d.* The chief item of non-recurring expenditure was the sum of £508 11*s.* 11*d.*, being the cost of the redecoration of the Society's apartments. The balance remaining available for the current year was £403 12*s.* 3*d.*

The Council announced the completion of vol. lvii and the commencement of vol. lviii of the Society's Quarterly Journal.

It was stated that Mr. C. Davies Sherborn had undertaken to continue during the year 1902 the preparation of the Catalogue-slips which the Society supplies to the Regional Bureau of the International Catalogue of Scientific Literature. Further, the services of Mr. Sherborn had been secured for the preparation of a new Library Catalogue.

Reference was made to the work, which the Rev. J. F. Blake had offered to undertake without remuneration, and upon which he was now engaged, of editing and preparing for publication a catalogue of the type- and other important specimens in the Society's Museum. Reference was also made to the pamphlet by the Rev. J. F. Blake, entitled "Suggestions for Certain Improvements, 1901," which had been under the consideration of the Council.

The establishment of the Trust which will henceforward be known as the Daniel Pidgeon Fund was announced, and the list of awards of the various Medals and proceeds of donation funds in the gift of the Council was read.

The report of the Library and Museum Committee enumerated the extensive additions made to the Society's Library, and mentioned that considerable progress had been made with the work of glazing the drawers in the Museum.

The reports having been received, the President handed the Wollaston Medal, awarded to Dr. Friedrich Schmidt, F.M.G.S., of St. Petersburg, to Professor H. G. Seeley, for transmission to the recipient, addressing him as follows :—Professor Seeley,—

Friedrich Schmidt is our chief living authority upon the rocks and fossils of the Baltic Provinces of Russia. The work of ascertaining the order and organic remains

of the richly fossiliferous strata of Esthonia, from the base of the Cambrian to the summit of the Devonian, originally commenced in broad outline by Eichwald, Pander, and others between the years 1830 and 1850, was taken up in great detail in 1853 by Schmidt, who was at that time Professor at the University of Dorpat. In the year 1856 he published his first work, "Die Silurische Formation von Estland, Nordlivland, und Œsel," which at once became the standard, and was referred to in detail by Murchison in his own paper on the subject in the Quarterly Journal of this Society for 1857. Even at this time Professor Schmidt had recognized between 400 and 500 fossils in these Esthonian rocks, had separated the Lower and Upper Silurian faunas, and had proved the existence of *Eurypterus* and *Cephalaspis* in the highest beds of his country.

For the next thirty years he continued these researches, and by the year 1882 he had completed a general survey of the region, had separated the Lower Palæozoic formations into the three faunal divisions of Cambrian, Ordovician, and Silurian, and distinguished some fifteen zones and sub-zones in the collective succession. He also published a map showing the distribution of the major zones, in readiness for the International Geological Map of Europe. Dr. Schmidt's results have enabled the whole of the Russian Palæozoic Series to be paralleled with the corresponding rocks of Scandinavia and other parts of the world.

In constant connection with the stratigraphical work, he has especially busied himself in the development and description of the palæontology of the Palæozoic succession. He has figured and described the Trilobites of the entire series, publishing the first part of his "Revision der Ostbaltischen Silurischen Trilobiten" in 1881, the fourth part in 1894, and the fifth part in 1898. He has also worked out the Eurypteridæ and the Leperditiadæ, the final parts of this work appearing in 1900. In 1888 he made known the discovery of *Olenellus* in the Lower Cambrian rocks of Esthonia, and he has subsequently described and figured the first Russian *Olenellus* (*O. Michwitzia*).

Dr. Schmidt's work, both palæontological and stratigraphical, bears the impress of unsparing labour, modest caution, and thoroughness; and the results that he has obtained have been invaluable in the development of our knowledge of the geology and fossils of the Baltic Provinces. He is one of the last survivors of the heroic age of geology, being the contemporary and occasional colleague of Eichwald, Pander, Kayserling, De Verneuil, Murchison, and Barrande. The award of our Wollaston Medal to this eminent Russian geologist and palæontologist is not only expressive of our hearty recognition of his lifelong devotion to the study of the rocks and fossils of his native land, but is also a grateful acknowledgment of the important services which he and his countrymen have rendered to the general advancement of geological science.

Professor Seeley replied in the following words :—Mr. President,—

Dr. Friedrich Schmidt desires to express his thanks for the honour of the award of the Wollaston Medal, and to say how much he regrets his inability to be present here, for he gratefully appreciates this expression of generous sympathy with his work. In early life he wandered through Siberia, where he learned the English language, which enabled him to contribute to the Society's Journal.

I have known Dr. Schmidt as Administrator of the Geological Museum of the Imperial Academy of Sciences of St. Petersburg, where I examined the materials described in his memoirs; and, in common with members of the International Geological Congress, I have been guided by him along the southern coast of the Gulf of Finland, from St. Petersburg to Œsel, to the principal scenes of his work in the Cambrian and Silurian rocks and Drift-deposits in the Eastern Baltic Provinces of Russia. And I may be permitted to say that all his work seems to me characterized by breadth of treatment and lucidity. In Schmidt the gifts and attainments of the naturalist illuminate the work of the geologist; and his search for truth never wearies and never hastes till all available facts are brought into illustrative relation with his research. His many-sided studies of nature have given a philosophical character to all Dr. Schmidt's contributions to science; and it is impossible not to realize that his scientific writings, which are many and valuable, give but inadequate expression to a personality which has powerfully influenced many to follow his methods and emulate his results. He has passed his 70th year, but works on, and looks forward to soon completing his final memoirs on the Trilobites.

He will warmly appreciate the terms in which the presentation of the Medal has been made, no less than the manner in which the Geological Society has endorsed the award of the Council.

The President then presented the Balance of the Proceeds of the Wollaston Donation Fund to Mr. Leonard James Spencer, M.A., F.G.S., of the Mineralogical Department, Natural History Museum, addressing him as follows:—Mr. Spencer,—

Your researches in Scientific Mineralogy during the last seven years constitute an important and solid contribution to natural knowledge. It is appropriate that the Council of this Society should mark their recognition of your labours by awarding to you the Balance of the Proceeds of the Wollaston Fund, which was instituted to promote researches concerning the mineral structure of the Earth.

In a series of papers on individual species you have shown yourself to be a master of the methods of crystallographic and mineralogical research, and you have applied these methods with signal success to the investigation of difficult minerals, some of which had baffled the efforts of previous workers.

Special interest attaches to those researches which you have carried out in collaboration with Mr. Prior, to whom this Fund was awarded two years ago, since these have led to the elucidation of species which had previously been misinterpreted, and have proved the identity of several rare minerals which were formerly ranked as different species. The most conspicuous instance is your joint study of Binnite, whereby that mineral, regarded for 45 years as a distinct species, was proved to be identical with the well-known mineral Tennantite.

Such researches naturally attract little attention outside the circle of mineralogists, but they are the sort of researches upon which accurate science is based.

The Council have pleasure in marking their appreciation of your patient and effective labours, by this award, and hope that their recognition of your work will encourage you to proceed with similar investigations.

In presenting the Murchison Medal to Mr. Frederic William Harmer, F.G.S., the President addressed him in the following words:—Mr. Harmer,—

The Council of this Society have awarded to you the Murchison Medal, in recognition of your long-continued labours among the Pliocene and later deposits of East Anglia.

In speaking of your earlier work, it is impossible to separate your name from that of Searles V. Wood, jun., who, I believe, discovered you on the Cromer coast nearly forty years ago, when you were trying to solve the riddle of its complicated Drifts. Wood, who had previously made a Drift Survey of the whole of Essex on the scale of 1 inch to the mile, soon enlisted your services in Norfolk while he continued his work in Suffolk; and in the course of about four years you were together able to bring before the British Association at Norwich a summary of the results at which you had arrived from the mapping of the Crag and Glacial Beds. Your map was published on a reduced scale by the Palæontographical Society in 1872, with a memoir in which you and Mr. Wood elaborated many points touched upon in your previous work. These original surveys formed an excellent basis for your further researches into the structure and method of formation of these deposits, and for the labours of all who have followed in your footsteps. Freed from the cares of business and of municipal duties, which occupied much of your time in earlier years, your attention has latterly been given to a study of the minuter divisions of the Crag Series, not only in this country, but abroad—in Holland and Belgium: thereby, dealing with the zonal succession in the Crag Series and with the distribution of molluscan life generally in the Pliocene Period, you have enlarged our knowledge of the physical and climatal conditions under which both Pliocene and Pleistocene deposits were laid down, and have drawn especial attention to the way in which meteorology can aid in the solution of geological problems.

While it is a matter for regret that Searles V. Wood, jun., did not live to receive from this Society any token of its appreciation of his labours, it is a great satisfaction to place this Medal in the hands of his partner, who has so strenuously carried on the work with which his name will always be associated.

Mr. Harmer replied as follows:— Mr. President,—

It is impossible to thank the Council as I could wish for the great honour that they have conferred on me, or yourself, sir, for the words which you have just spoken. The pleasure that this award gives to me has been much increased by your kind reference to my dear old master and friend, Searles V. Wood the younger, with whom, as you have said, I had so long the privilege of working: to whom, indeed, the credit of anything that I was able to accomplish in my younger days is largely due. I am glad to think that this Medal recognizes also the value of the far more important labours of the distinguished man to whose teaching and influence I owe so much.

I regret that during my best years the demands on my scanty leisure left me no time for geological investigation, and that I have only been able to return to it in the evening of life: first, because I can hardly expect to do much to show myself more worthy of this great distinction; and next, because I shall have to leave to my successors many important and interesting problems in East Anglian geology, in the solution of which I once hoped to have taken part.

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Mr. Thomas H. Holland, F.G.S., of the Geological Survey of India, addressing him in the following words:—Mr. Holland,—

The Records of the Geological Survey of India, the Journal of this Society, and other periodicals bear testimony to your scientific activity during the past decade. I can only refer to a few of your more important contributions to the advancement of science.

In your Memoir on the Charnockite Series you have made us familiar with the field-relations, the mineralogical composition, and the microscopic structure of an important and interesting group of Archæan rocks; in your contribution to the "Manual of the Geology of India" you have given us a valuable treatise on the natural history of Corundum; and in your paper on the Eläolite-Syenites of Sivamalai you have added a new group to the foliated crystalline series.

But you have not confined your attention to the crystalline rocks. In the "Report on the Geological Structure and Stability of the Hill-Slopes around Naini Tal" you have brought your geological knowledge to bear on questions affecting the security of life and property, and have laid down general principles which must be of great utility to all those who are responsible for the safety of the inhabitants of those hilly districts, in which denudation is going on with exceptional rapidity.

I have much pleasure in handing you the Balance of the Murchison Geological Fund, which has been awarded to you by the Council of the Geological Society in recognition of your valuable contributions to Indian Geology.

In handing the Lyell Medal awarded to Mr. Richard Lydekker, B.A., F.R.S., to Dr. F. A. Bather for transmission to the recipient, the President addressed him as follows:—Dr. Bather,—

Mr. Lydekker's labours in the domain of Vertebrate Palæontology commenced, I believe, with a study of the Siwalik fossils, which resulted in numerous and valuable additions to the classic work of Falconer & Cautley on the Siwalik Fossils.

Many other Tertiary Vertebrata from various parts of India and Burmah, from Perim Island, Sind, the Nerbudda, and the Irrawaddy Valley, have been examined and described by him. He has also given us an account of the Pleistocene fauna of the Karnul caves, and has contributed to our knowledge of Indian Mesozoic Reptilia.

During his residence in India as an Officer of the Geological Survey he was necessarily much occupied with field-work; and we have to thank him for a detailed account of the vast mountainous area comprised within the territories of Kashmir.

Since his return to this country he has not been idle. He has contributed no less than ten volumes to the Official Catalogue of the British Museum; he has visited the Museums of Argentina and added much to our knowledge of the remarkable Tertiary fauna of South America; and he has furnished to this and other Societies numerous descriptions of Vertebrata from the Mesozoic and Tertiary formations of various countries. His extensive knowledge of fossil forms has enabled him to contribute to

two of the most remarkable zoological books published during the last decade of the nineteenth century. I refer to "Mammals, Living and Extinct," by Sir William Flower and him, and to the "Dictionary of Birds" by Professor A. Newton. Of late years he has devoted himself more especially to the study of recent forms; but in his work on the Geographical History of Mammals he has successfully brought his wide knowledge of the mammalian life of past times to bear on the important question of geographical distribution.

As an old fellow-student of his at Cambridge it gives me the greatest pleasure to be the means of transmitting to him the Lyell Medal on behalf of the Council of the Geological Society. In making the award the Council desire especially to commemorate the important services which he has rendered to Vertebrate Palæontology.

Dr. Bather, having expressed on behalf of the recipient the latter's regret that an engagement at Norwich prevented him from being present in person to receive the Medal, read the following communication from Mr. Lydekker:—

"The award of a Lyell Medal would under any circumstances be a cause of great gratification to the recipient. But I have special reason to be gratified at the reward that the Council have been good enough to bestow on me, because in matters scientific I seem to have passed unconsciously through a kind of evolutionary process, and to have departed further and further from the line of study connected with the Geological Society. During my term of service on the Geological Survey of India I was largely occupied with Geology proper, although devoting a considerable proportion of my time to Vertebrate Palæontology. For several years after my return to this country that fascinating subject occupied the greater share of my attention. But of late years I have been led by the force of circumstances to transfer my time more and more to recent animals and geographical distribution. Moreover, I regret to say, much of my time has been given to popular or semi-popular writing rather than to strictly scientific work. Under these circumstances it is especially gratifying to find that the Geological Society is not unmindful of my past efforts to add to our knowledge of extinct Vertebrates; a task which I hope, as opportunity occurs, may to some extent be resumed in the future. To you, sir, as representing the Council, I have the pleasure of tendering my best thanks for the honour now conferred upon me; and I may add that my pleasure is intensified by receiving the award at the hands of a Cambridge contemporary who has risen to the distinguished position now occupied by yourself."

The President then handed another Lyell Medal, awarded to Prof. Anton Fritsch, F.M.G.S., of Prague, to Prof. H. G. Seeley for transmission to the recipient, addressing him in the following words:—Professor Seeley,—

The Council of the Geological Society have awarded a Lyell Medal to Dr. Anton Fritsch, of Prague, in evidence of their appreciation of the value of his published works upon the Palæontology of Bohemia. In 1872, 1878, and 1887 Professor Fritsch gave us a series of volumes on the Cephalopoda, Reptiles, Fishes, and Crustacea of the Bohemian Cretaceous Rocks. But he is best known by his researches in Palæozoic Palæontology. Twenty years ago, after the publication of the first results of his labours on the Fossils of the Pilsen Coal-basin, this Society made to him an award from the Lyell Geological Fund. It is fitting, therefore, that he should receive the Lyell Medal on the completion of this great work, which represents twenty-five years of strenuous labour, and has gained for its author a position of great eminence in the palæontological world.

Much of the material with which he has had to deal would probably have been neglected by less accomplished observers. By careful drawing with his own hands, and by the aid of electrotype reproductions of perishable parts, he has brought vividly before us a new Permian terrestrial fauna, remarkable for its labyrinthodontia, fishes, arachnida, insects, and myriapoda. Professor Fritsch has not only described a vast amount of new palæontological material, but he has also used the knowledge thus gained for the purpose of elucidating the affinities of the different extinct groups with each other and with their nearest living allies.

His studies of Labyrinthodontia demonstrated the wide range of structure in animals included in that group, and suggested the approximation of the several subdivisions which he described to different orders of reptiles.

In conveying this Medal to Dr. Fritsch I ask you to express to him our sympathy with his labours in palæontology which have been carried on for fifty years, and our satisfaction at the completion of his great work on the Permian Fauna of Bohemia.

Professor Seeley replied as follows:—Mr. President,—

It is a great pleasure to receive the Lyell Medal on behalf of Professor Fritsch. He has successfully overcome difficulties in the mineral condition of material which might have stopped a less resolute man. His work, enriched with all the learning which a comparative anatomist could bring to palæontological problems, will, I believe, always rank as one of the more important contributions to knowledge made in the latter half of the nineteenth century. The Medal came as a happy surprise to Professor Fritsch, and he writes to me:—

"In awarding to me the proceeds of the Lyell Fund twenty-five years ago the Society encouraged me in the heavy work of describing the rich fauna of the Permian strata in Bohemia, which I have happily finished after thirty years of labour.

"This second award will strengthen me to devote the rest of my life to further elaboration of the beautiful palæontological materials in our Museum. The new revision of the Carboniferous Arachnida and descriptions of two large Saurians from our Chalk formation, on which I am at work, will be the best thanks that I can pay to the Geological Society for this generous gift."

The President then presented the Balance of the Proceeds of the Lyell Geological Fund to Dr. Wheelton Hind, F.R.C.S., of Stoke-on-Trent, addressing him as follows:—Dr. Wheelton Hind,—

The Council of the Society have awarded to you the Balance of the Proceeds of the Lyell Fund as a mark of their appreciation of your enthusiastic labours among the Carboniferous rocks of this country. During the past twelve years, while residing in the interesting region of the Potteries, and largely occupied in arduous professional work, you have found time for a detailed study of the rocks and fossils of your district, and more especially of the neglected lamellibranchs of the Coal-measures. Extending your labours into bordering and even distant Carboniferous areas, you have not only enriched our knowledge of the stratigraphical divisions, but you have initiated a study of the life-zones—a study which has borne good fruit, and in which we anticipate from you further important results. In addition to this, we are further indebted to you for the monographs on Carboniferous Mollusca which you have contributed to the Palæontographical Society.

In handing the Proceeds of the Barlow-Jameson Fund, awarded to Mr. William Maynard Hutchings, F.G.S., of Newcastle-upon-Tyne, to Mr. George Barrow for transmission to the recipient, the President addressed him as follows:—Mr. Barrow,—

In the midst of a busy professional life Mr. Hutchings has found time to carry out a series of laborious petrographical researches, and to contribute a number of important papers to the Geological Magazine and other scientific journals.

He has especially directed his attention to the composition of the finer-grained sedimentary rocks, and to the changes which are produced in them by normal decomposition and contact-action. The rocks on which he has worked have been comparatively neglected by petrologists, in consequence of the difficulties attending their investigation, but he has shown that, by the use of suitable sections and very high powers, these difficulties can be successfully surmounted.

The Council of the Geological Society have awarded to Mr. Hutchings a grant from the Proceeds of the Barlow-Jameson Fund, as a mark of their appreciation of his contributions to petrographical science, and as an expression of the hope that, in the future as in the past, he will be able to carry on the researches which have thrown so much light on the natural history of our sedimentary rocks.

The President then proceeded to read his Anniversary Address, in which he first gave obituary notices of several Fellows deceased

since the last annual meeting, including Dr. G. M. Dawson (elected in 1875), Professor E. W. Claypole (el. in 1879), the Hon. Clarence King (el. in 1874), Mr. J. H. Blake (el. in 1868), Professor Ralph Tate (el. in 1861), Mr. J. Shipman (el. in 1885), the Rev. Frederick Smithe (el. in 1858); Professor Gustav Lindström (el. For. Memb. in 1892), and Baron A. E. Nordenskiöld (el. F.M. in 1880).

He then dealt, in continuation of the address delivered last year, with the evolution of petrological ideas as regards the sedimentary and metamorphic rocks.

The influence of the growth of knowledge as to the nature of the sedimentary rocks, the chemical and physical processes involved in their formation, and the deposits now forming, was traced in more or less detail. Special attention was directed to the importance of experimental research, suggested and controlled by an intimate knowledge of the facts of geology.

It was pointed out that the natural history of our sedimentary formations requires for its elucidation, not only a study of the phenomena taking place in sea-basins and areas of open drainage, but of those of desert regions and areas of closed drainage; and that the recognition of this fact by Ramsay and others marks a distinct advance in the evolution of ideas. The researches in desert regions by W. T. Blanford, O. Fraas, Schweinfurth, J. Walther, and others were referred to, and their results epitomized.

In the part relating to crystalline schists it was pointed out that, if gneissose rocks of original igneous origin be left out of account, the remainder consist for the most part of metamorphic rocks; and the growth of opinion on the subject of metamorphism as applied to crystalline schists was briefly traced. The idea that mixed rocks might be formed by the intrusion of one kind of igneous rock into another or into a sedimentary rock was favourably reviewed, and its bearing on the origin of certain crystalline schists was indicated.

The theory of dynamo-metamorphism was commented on; and it was pointed out that the advocates of the theory had not suggested that the deformation which resulted in the production of holocrystalline schists took place at ordinary surface temperatures.

In conclusion it was pointed out that, although great progress had been made in the interpretation of crystalline schists, our stock of ideas was insufficient to furnish a complete and satisfactory account of their origin.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council:* F. A. Bather, M.A., D.Sc.; W. T. Blanford, LL.D., F.R.S.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; Professor E. J. Garwood, M.A.; Sir Archibald Geikie, D.Sc., D.C.L., LL.D., F.R.S. L. & E.; Professor T. T. Groom, M.A., D.Sc.; Alfred Harker, Esq., M.A.; R. S. Herries, Esq., M.A.; W. H. Hudleston, Esq., M.A., F.R.S., F.L.S.; Professor Charles Lapworth, LL.D., F.R.S.; Lieut.-Gen. C. A. McMahon, F.R.S.; J. E. Marr, Esq., M.A., F.R.S.; Professor H. A. Miers, M.A., F.R.S.; Right Rev. John Mitchinson, D.D., D.C.L.; E. T. Newton, Esq., F.R.S.; G. T. Prior, M.A.; D. H. Scott, M.A., Ph.D., F.R.S., F.L.S.; Professor H. G. Seeley, F.R.S., F.L.S.; Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S.; Arthur Sopwith, Esq., M. Inst. C.E.; J. J. H. Teall, Esq., M.A., F.R.S.; Professor W. W. Watts, M.A.; Henry Woodward, LL.D., F.R.S.

Officers :—President : Prof. Charles Lapworth, LL. D.,F.R.S. *Vice-Presidents :* Sir Archibald Geikie, D.Sc., D.C.L., LL.D., F.R.S. L. & E. ; J. E. Marr, Esq., M.A., F.R.S. ; Professor H. A. Miers, M.A., F.R.S. ; Professor H. G. Seeley, F.R.S., F.L.S. *Secretaries :* R. S. Herries, Esq., M.A. ; and Professor W. W. Watts, M.A. *Foreign Secretary :* Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer :* W. T. Blanford, LL.D., F.R.S.

II.—February 26th, 1902.—Prof. Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read :—

1. "On some Gaps in the Lias." By Edwin A. Walford, Esq., F.G.S.

The author's endeavour is to prove gaps in the stratigraphical succession of the Lias, involving the removal of zones or parts of zones, and also to prove palæontological gaps by the abrupt appearance of many new genera of mollusca.

The Middle Liassic ferruginous limestone of the zone of *Ammonites spinatus* he states to be mainly made up of a kind of crinoid (ferrocrinoid). The zone may be divided into

2. The Ferrocrinoid bank—upper. 30 feet.
1. The *Spirifer oxygona* beds—lower. 20 feet.

The upper division varies from 30 feet at an altitude of 700 feet to 6 feet at the altitude of 350 feet on the edges of the Cherwell Vale, owing to waste by drainage. The upper zone is of great thickness and importance in Oxfordshire and Yorkshire (Cleveland), but almost absent in Dorset, Somerset, and Gloucestershire, where the fauna of the lower *Spirifer oxygona* beds prevails. The ironstone is thickest towards the escarpment on the west of the Cherwell Vale ; on the east side of the vale it loses both in type and importance. At Bloxham a course of ferruginous limestone is made up of stems of the ferrocrinoid in great part, but near the top it becomes a pink compact limestone, full of fossils of the zone of *Ammonites communis* : the intermediate transition-bed and zone of *Ammonites serpentinus* having been removed by inter-waste rather than by contemporaneous erosion.

A transition-bed between the Middle and Upper Lias shows a great incoming of new forms. They are no doubt developed outside lines of known strata.

A third gap, measured by the occurrence of a thin bed of Pentacrinite-limestone, is in the zone of *Ammonites communis.*

The '*spinatus*-ironstone' is believed to lose in thickness on the side of a divide away from the main west-to-east dip. On the Northamptonshire side of the Cherwell, where the slope is to the west, and hence opposite to the general dip, the beds are thin, although the argillaceous beds are better preserved.

2. "On the Origin of the River-System of South Wales, and its Connection with that of the Severn and Thames." By Aubrey Strahan, Esq., M.A., F.G.S.

The southerly courses of some rivers from the Usk to the Ogmore are described, and shown to be independent of both the east-and-west

folding and the north-north-westerly faulting of the rocks on which they lie. Farther west the drainage system takes a different direction, the rivers coinciding so closely with a set of west-south-westerly disturbances as obviously to have been determined in direction by them.

Of the three systems of disturbance alluded to, the east-and-west (Armorican) folding was pre-Triassic; it marks a period of compression with impulse from the south, and though it reached great intensity in Devon, Somerset, and South Wales, it died away in Central Wales. The north-north-westerly (Charnian) faulting, though partly of pre-Triassic age, was renewed in post-Eocene times, and is manifested over much of the British Isles. It marked periods of relief from pressure, and of subsidence. The west-south-westerly (Caledonian) folding was the latest; it marked a period of compression, with impulse from the north, and displayed greater energy in Central than in South Wales. It gave rise to a series of subsidiary disturbances in the latter region, and initiated and controlled the river-system. The ignoring by the rivers of the structures due to the earlier disturbances is attributed to the Palæozoic areas having been overspread by Upper Cretaceous rocks at the time of the initiation of the river-system.

The eastward course of the Upper Severn is attributed to the upheaval of a main axis (now the main water-parting) in Central Wales. Its deflection to the south and south-west was due to the formation of an anticline in the Chalk, which must have been parallel to, but a little west of, the present Chalk escarpment, and which was parallel to, and contemporaneous with, the Caledonian disturbances in Wales.

This anticline, acting in combination with the Armorican folding displayed in the London and Hampshire basins initiated the systems of the Thames and Frome. Those systems were initiated in post-Oligocene and pre-Pliocene times, and the same age is inferred for the systems of South Wales and of the Severn.

III.—March 12th, 1902.—Sir Archibald Geikie, D.C.L., LL.D., F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "The Crystalline Limestones of Ceylon." By Ananda K. Coomára-Swámy, Esq., B.Sc., F.L.S., F.G.S.

The crystalline rocks of Ceylon may be divided into three series:—

(1) The Older Gneisses.
(2) The Crystalline Limestones.
(3) The Granulites (Charnockite Series)—pyroxene-granulite, leptynite, etc. A local subdivision of this series is the Point de Galle Group—wollastonite-scapolite-gneisses, etc.

The crystalline limestones of Ceylon are intimately associated with the banded pyroxene and acid granulites (Charnockite Series).

They form bands with outcrops from a few feet to over a quarter of a mile in width, interbedded with the granulites. The limestones themselves have a banded structure (foliation) parallel to that of the granulites and to the boundaries. This foliation of the limestone depends on variations in structure, amount of accessory minerals, and relative proportion of calcite and dolomite. The grain is coarse, sometimes exceedingly so. Parallel and graphic intergrowths of calcite and dolomite are very characteristic. The most abundant accessory minerals are olivine, phlogopite, pink or violet spinel, diopside, pyrite, and blue apatite; less common are amphiboles, clinohumite, green spinel, etc. The most characteristic contact-minerals are diopside, amphibole, green spinel, and greenish micas; and, rather in the granulite than the limestone, scapolite, phlogopite, diopside, sphene. There occur also in the limestones, nodular mineral aggregates composed of characteristic minerals such as diopside, phlogopite, blue apatite, and spinel.

There are often transitions between the limestones and granulites. In some other cases a zone of green rocks (with diopside, dark mica, amphibole, and green spinel) intervenes. Bands (sills) of granulite of various width, down to less than a foot, may occur in the limestone, and are parallel to the foliation and general strike. These show peripheral transitions to the limestone by incoming of original calcite and the appearance of lime-silicates, or are separated from it by a zone a few inches wide, in which the minerals diopside, amphibole, and green spinel are characteristic.

Some interrupted sills are described, and compared with the interrupted dykes of nepheline-syenite in the crystalline limestones of Alnö, described by Professor Högbom. A sill may thus be continued along the strike as a series of lenticles. Elsewhere quite isolated masses of pyroxene-granulite occur as inclusions in the limestone.

Although the relation of the granulites to the limestones is on the whole intrusive, the two rocks in their present condition are essentially contemporaneous, and seem alike to have consolidated from a molten magma. The calcite occurring in the granulites near the contact has all the appearance of an original mineral. The foliation of the limestone is regarded as a sort of flow-structure, and corresponds with that of the granulites to which it is always parallel. That the foliation does not result from the action of earth-movements on a solid rock is shown by this, that the very minerals whose variable distribution is one of its chief causes, have certainly not been affected by deforming earth-movements, nor are they such as to have been produced by these; moreover, in this respect a distinction cannot be made between the limestones and granulites, which would necessarily have suffered alike had they been subjected to deforming strains since the consolidation of the latter. The original nature of the limestones is less evident: they may have been sedimentary or tufaceous, and, if so, subsequently softened and metamorphosed; or possibly *ab initio* truly igneous rocks, and related to the charnockite-magma. Reasons for and against these views are given.

The relations between the crystalline limestones and nepheline-syenites of Alnö have suggested to Professor Högbom that perhaps the limestones may have been a product of the nepheline-syenite magma there.

The author feels sure that the crystalline limestones of Ceylon have not arisen by the alteration of the basic lime-silicates of the pyroxene-granulites, although Professor Judd has advanced this theory in connection with the crystalline limestones of Burma, which seem to resemble those of Ceylon in many ways.

2. "On Proterozoic Gasteropoda which have been referred to *Murchisonia* and *Pleurotomaria*, with Descriptions of New Subgenera and Species." By Miss Jane Donald. (Communicated by J. G. Goodchild, Esq., F.G.S.)

Many of the Palæozoic shells referred to *Murchisonia* do not agree with the type, and there are at least two separate groups distinguished by the outer lip. The typical growth has a slit, the other merely a sinus. As the outer lip is rarely well preserved, it is difficult and sometimes impossible to decide whether a particular individual belongs to one or other of these two types. With regard to these shells, two important questions require to be answered. Firstly, whether the slit or the sinus characterizes the more primitive type; and secondly, whether the elongated *Murchisonia* and the shorter *Pleurotomaria* are both derived from the same stock, and which of them appears the earlier. Before considering the British evidence the work of foreign palæontologists is reviewed by the authoress. From the material at present available, in the British Isles as well as in America and the Baltic Provinces, elongated forms with a sinus precede those with a slit. There are at least two distinct groups of sinuated shells with a band: one, containing *Hormotoma*, *Ectomaria*, etc., having the lines of growth sweeping back to and forward from the band very obliquely; and a second, containing *Lophospira*, having the lines less oblique and agreeing more in direction with those of *Murchisonia*, only the band is prominent instead of being grooved. A possible third group is indicated by a subgenus, subsequently described, in which the lines of growth are but slightly oblique and the band grooved. The first two groups in Britain range from Upper Cambrian to Silurian rocks, and the third from the Bala to the Silurian. The genus *Murchisonia* may have begun in the Wenlock formation. So far, no light is thrown on the question as to whether *Murchisonia* and *Pleurotomaria* were derived from the same stock, nor has the authoress yet met with any specimens showing a transition from sinus to slit.

In the latter part of the paper three new subgenera, eleven new species, and one new variety are described and figured.